SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

JANUARY 1901.

GENERAL PHYSICS.

1. *Hardness of Metals.* **F. Auerbach.** (Ann. d. Physik, 3. 1. pp. 108–115, Sept., 1900.)—The author's definition of hardness is given for the case of plastic bodies, including metals, by the limiting pressure per unit surface, attainable between a lens and a plate of the same substance. In the case of metals the deformation cannot be observed with the same facility as in the case of transparent bodies, but the surface of contact may be measured by covering the lens with a thin layer of lampblack. This is only necessary at small pressures, since at great pressures the deformed area retains its shape. A complication is introduced by the fact that the hardness is considerably influenced by small impurities, as well as by the elastic and thermal history of the metal. The author gives the following table of the hardnesses of various fairly well-defined metals, as compared with minerals :—

Steel	361	Quartz.
Copper (hard)	143	Apatite.
Bronze	127	
Brass	107	Fluorspar.
Gold	97	Calcspar.
Copper	95	
Silver	91	
Aluminium	52	Boracic Acid.
Lead	10	Gypsum.

The aluminium was alloyed with 6 per cent. copper. The bronze was an alloy of 15 parts copper, 2 parts zinc, and 1·5 tin. The brass contained 2 parts copper to 1 of zinc. **E. E. F.**

2. *Elasticity and Hardness of Silica.* **F. Auerbach.** (Ann. d. Physik, 3. 1. pp. 116–119, Sept., 1900.)—Silica was obtained in three forms : crystallised as rock crystal, amorphous as a glass, and amorphous with admixture of water in the form of opal. In every case the hardness is sensibly proportional to the elasticity, except in glass, which is somewhat harder. Both the elasticity and the hardness of the amorphous silica are smaller than the smallest values for rock crystal. The elasticity and hardness

of opal are only about half those of amorphous silica. The first difference is probably connected with the fact that quartz expands during amorphous solidification, its density then being only 83 per cent. of its density as rock crystal. The softness of opal is due to the admixture of water. E. E. F.

3. *Elasticity of Metals, and Temperature.* **A. Gray, V. J. Blyth,** and **J. S. Dunlop.** (Roy. Soc., Proc. 67. pp. 180–197, Oct. 31, 1900.)—The Young's and rigidity moduli of several different metals in the form of wires are here determined at different temperatures between atmospheric temperature and 100° C. The metals used were German silver, mild steel, brass, copper (commercial), copper (hard-drawn electrolytic), and soft iron, and the results are given in tabular form in the paper. In determining the rigidity moduli by the vibration method, the authors noticed that temperature has a considerable effect on the decrement of the vibrations. The decrement appears to be a function of the temperature and of the amplitude of vibration, but the authors purpose experimenting still further on this point. German silver appears to behave differently from all the others in this alteration of decrement with temperature, the decrement being smaller at the high temperatures in its case, instead of larger as in the case of the others. The decrement is also a function of the weight of the vibrator and of the previous history of the wire. J. B. H.

4. *Contact Deformations of Elastic Bodies.* **A. Lafay.** (Comptes Rendus, 131. pp. 525–528, Sept. 17, 1900.)—The author describes experiments on the deformations of two spheres in contact with each other, or a sphere in contact with a plane, the materials being generally bronze or steel. The method of measuring these deformations is an optical one analogous to that employed by Fizeau for studying the dilation of crystals. The radii of the spheres used varied from 5 mm. to 250 mm., and the force of compression from a few grammes to 3·7 kg. A table is given of results which vary from 0·14 microns for steel spheres of radius 250 mm., pressed together with a force of 0·1 kg., to 2 microns for spheres of radius 5 mm., and a force of 3·0 kg. These values are compared with the theoretical deformations as given by Hertz's mathematical theory of elasticity. E. C. R.

5. *Elasticity of Wires.* **H. E. Wimperis.** (Phil. Mag. 50. pp. 416–420, Oct., 1900.)—In the Phil. Mag. for Feb., 1900 [see Abstract No. 795 (1900)], G. F. C. Searle described an apparatus for determining the elastic constants for wires of different metals. With it he found the value of Poisson's ratio for certain metals greater than $\frac{1}{2}$. The author extends these experiments to wires of larger diameter (from $\frac{1}{16}$ inch to $\frac{1}{4}$ inch), the diameters of the wires used by Searle being from $\frac{1}{25}$ inch to $\frac{1}{16}$ inch. The apparatus used is similar to Searle's but much larger, the moment of inertia of the vibrating rods being six times as great. The paper gives a description of the apparatus and method of using it. In no case was the value of Poisson's ratio found greater than 0·461; this, in view of Searle having obtained several values above 0·5, is of interest as illustrating a possible effect of the increase of diameter of the wires used. E. C. R.

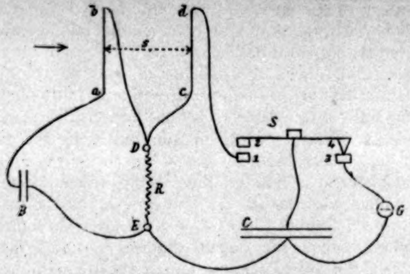
6. *Explosive Effects of Bullets.* **C. Cranz** and **K. R. Koch.** (Ann. d. Physik, 3. 2. pp. 247–278, Oct., 1900.)—The question investigated by the authors was whether the "explosion" of tissues produced by a high-velocity infantry bullet takes place while the bullet is still within the body, or after it

has already left it. To imitate the action of blood-vessels while having recourse to a clearly defined physical structure, the authors employed tin cylinders filled with water, and closed at one end with parchment, and at the other with an indiarubber membrane. The rifle experimented with was a new 6 mm. model made by Mauser at Oberndorf, and having a muzzle velocity of 100 m. in excess of any hitherto used. The method of taking the photographic records was a modification of that devised by Mach. The circuit of a battery of Leyden jars was interrupted by two spark-gaps. One of them lies within the liquid, or in its immediate neighbourhood. Its knobs are covered with glass tubes, so that the spark can only pass when they are shot through. The other spark-gap lies in front of a concave mirror in such a position that its image falls on the shutter of the recording camera. This gives a silhouette of the water-vessel on the sensitive plate. In some of the experiments, the bending aside of the bullet by the water made it necessary to have another method of making the circuit. This was then done by the mechanical action of the issuing water-jet in bringing one electrode into contact with the other. The general result of the experiments is that the "explosion" takes place some time after the bullet has left the body. The authors discuss the various theories framed to account for the phenomenon. It is not due to evaporation, as the temperature of the bullet in no case exceeds 150°. The introduction of large masses of gas into the body has no evidence to support it. The rotation of the bullet is too slight to produce the effect, and the deformation of the bullet cannot be the main cause, as explosive effects are produced when there is no deformation. The only remaining theories are that based on sound waves and on the acquired velocity of translation. The authors favour the latter. Part of the kinetic energy of the bullet is transferred to parts of the body in the vicinity of the path of the bullet, and takes some time to produce its effect. But when this takes place a considerable portion of the body is torn away from the anterior portion. E. E. F.

7. *Permanent Deformations of Metallic Wires.* **E. Lenoble.** (Journ. de Physique, 9. pp. 532–543, Oct., 1900.)—This paper deals with the relations between the fractional increase in length of a wire stretched vertically and loaded at its lower end, and the load per unit of area. Arrangements were made for increasing and decreasing the load gradually. The experiments are divided into two classes—those with loads much under the breaking load, and those with loads in the vicinity of the breaking load. The wires were in most cases given a definite load, and this load increased by steps to a higher value, and then decreased by the same steps to the original value, this cycle being repeated over and over again until the hysteretic loop attained a limiting value. E. C. R.

8. *Measuring Speed of Bullets.* **M. Radaković.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 276–283, April, 1900.)—This paper describes a method of determining the velocity of a bullet by the time of discharge of a condenser, using the equation $q = q_0 \epsilon^{-\frac{t}{RC}}$ where q is the charge in condenser after t secs., q_0 is initial charge, R the resistance of a non-inductive discharger, and C the capacity of the condenser.

The condenser C is charged by the cell B on pressing the 1-2 side of the key S. On releasing the key the charge q_0 is found by means of the ballistic galvanometer G. Having carried out this preliminary measurement, the key 1-2 is pressed down, and the shot fired so as to sever the gratings *ab*, *cd*, in succession. This effects first the cutting out of the battery, and second the stopping of the condenser discharge. By releasing the key again the residual charge q is found; and hence t and v. Sabine used this method in 1876, but his results were not concordant. The author's experiments were made with an infantry rifle of 8 mm. bore, and the first screen *ab* was 10 metres from the muzzle. In one experiment B was a single accumulator cell, C 1·1 microfarad, R 1,354 ohms.



Values of v in metres per second were found as follows :—

s = 48·4 cm.	s = 28·6 cm.	s = { 8·85 cm. 8·5 cm.
611·2	598·9	599·3
607·6	633·5	631·0
631·4	...	...
Mean = 616·7	Mean = 616·2	Mean = 615·1

A weak E.M.F., good insulation, and a sensitive ballistic galvanometer are necessary for a successful determination of velocity, and the error in the measurement of t is smallest when $q/q_0 = 0{\cdot}278$. Other experiments showed there was no perceptible slowing down due to the resistance of the gratings shot through.
G. E. A.

9. *Thermal and Electrical Conductivities.* **E. Grüneisen.** (Ann. d. Physik, 3. 1. pp. 43–74, Sept., 1900.)—The author studies the influence of impurities in metals upon the ratio of their electric and thermal conductivities. The method of determining the thermal conductivity is that devised by Schulze [see Abstract No. 803 (1899)], but the bar of metal was itself made one of the elements of the thermo-couple. Eight different bars were examined. One of them was pure copper. A second, denoted by CuAs1, contained traces of arsenic; and a third, CuAs2, contained considerable traces of it. The fourth was an iron bar, denoted by FeWA14, and containing 0·1 per cent. carbon and traces of Cu, Si, Mn, P, and S. Another iron bar, FeWA2, contained 0·57 per cent. of carbon, and 0·21 of silicon. FeWA3 contained more carbon and less silicon, and FeWA4 contained 1·5 per cent. of carbon, 0·19 of Mn, and 0·05 Si. A nickel-copper alloy con-

taining 46 per cent. of Ni was also examined. The following table gives the results in c.g.s. units per 18° C.

Substance.	Electric Conductivity $\kappa \times 10^5$.	Thermal Conductivity λ.	$\frac{\lambda}{\kappa} \times 10^{-1}$.
Cu	57·4	0·934	163
CuAs1	19·1	0·840	178
CuAs2	5·03	0·0995	198
FeWA14	9·89	0·171	173
FeWA2	6·10	0·124	203
FeWA3	6·12	0·123	201
FeWA4	5·51	0·119	216
NiCu	1·99	0·0484	243

Addition of foreign substances reduces the electric conductivity to a greater extent than the thermal conductivity. This is specially evident in iron. The electric conductivities of the four iron bars are in the ratio

$$1 : 0·617 : 0·619 : 0·557.$$

The same ratios, calculated after Le Chatelier's rules, are

$$1 : 0·631 : 0·601 : 0·496,$$

neglecting the traces of phosphorus, sulphur, and copper. E. E. F.

10. *Electrical Weighing and Recording Machine.* **E. McGarvey.** (Scientific American, 83. pp. 104–105, Aug. 18, 1900.)—The weight is applied through levers to a steel ribbon in tension; this ribbon is vibrated by an electromagnet with interrupter on the ribbon, and the intermittent current produced is passed through a second electromagnet (which may be at any distance) acting on a similar steel ribbon. The second ribbon will only vibrate actively when its period is the same as that of the first, *i.e.*, when their tensions are equal; this condition is obtained by varying the weights on a steelyard supporting the second ribbon. When this is in active vibration the weight stretching it is the same as that applied to the first ribbon.

In the instrument for recording weights, the second ribbon is replaced by a plate carrying a series of metal reeds similar to the set of reeds in a musical-box; each reed is tuned in unison with the first ribbon when stretched by a definite weight. The plate carrying the reeds is vibrated in unison with the ribbon by an electromagnet, and the reed corresponding with the rate of vibration is set into active vibration. Recording is done as follows: A strip of paper is passed over an insulated metal roller at a slight distance below the tips of the reeds; the metal roller and the reeds are joined to the two poles of the spark-gap of an induction coil. When no reed is vibrating the distance between them and the roller is such that the sparks pass across their normal spark-gap; when any reed vibrates, however, it approaches so close to the roller that the spark passes and perforates the strip of paper. G. H. B.

11. *Helmholtz Pendulum Interrupter.* **M. T. Edelmann.** (Ann. d. Physik, 3. 2. pp. 274–282, Oct., 1900.)—The author describes the pendulum interrupter manufactured by himself on Helmholtz's principles, with especial reference to the various devices for accurately determining the time interval between the two successive contacts. E. E. F.

12. *Thickness of Films.* **C. H. Sharp.** (Ann. d. Physik, 3. 2. pp. 210–220, Oct., 1900.)—The thickness of a thin deposit is obtained by making a model of it in a mixture of equal parts of colophonium and burgundy pitch. At the place where the thickness is to be determined, a small portion of the film is removed, and the mixture is laid on and warmed to 75° in a thermostat. It is lightly pressed in with the finger, after which the whole is allowed to cool slowly, and the impression is lifted off. It has a brilliant black surface. It is pressed on to a glass plate, and two systems of interference fringes are seen, one corresponding to the film and the other corresponding to the blank space. The discontinuity between the two systems is indicated by a displacement of the fringes, and the amount of the displacement measures the thickness. The author has devised a special spectrometer arrangement for exact measurements. He has measured the thicknesses of various layers of gelatine by this method. When the impression is lifted off, it does not stick, owing to a slight contraction on cooling. This contraction, while sufficient to facilitate detachment, is not large enough to interfere with the correctness of the measurements, since the mixture remains practically liquid until it arrives at the ordinary temperature. E. E. F.

13. *Diffusion of Gases and Liquids.* **H. T. Brown.** (Chem. News, 82. pp. 161–162, Oct. 5, 1900. Abstract of a paper read before the British Association.)—The author has made interesting experiments on the rate of diffusion of CO_2 towards an absorbing KOH solution. If no diaphragm be used the rate of absorption is proportional to the *area* of the opening. If, however, a diaphragm be used in perfectly still air, "vena contracta" effects come in, and the rate of flow tends to become proportional to the *diameter* of the opening. F. G. D.

14. *Surface Tension of Water above* 100° *C.* **C. T. Knipp.** (Phys. Rev. 11. pp. 129–154, Sept., 1900.)—Owing to the way in which water attacks glass at high temperatures it was necessary to use some other material for the containing vessel. A steel vessel plated inside with platinum (or copper) was used. The method consisted in determining the force required to lift a platinum vane partly submerged in water. The force was obtained by utilising the ponderomotive force exerted by a coil carrying a current. The temperatures were measured by a Cu-Pt thermo-junction. The apparatus was electrically treated and the movement of the vane electrically signalled. The author determined not only the surface tensions (from 100° C. to the critical temperature) but also the critical constants. The critical temperature was found to be 359° C. and the pressure 205 atmospheres. The surface tension was found to decrease linearly with increase of temperature until near the critical temperature, when it fell to zero very rapidly. F. G. D.

15. *Measurement of Surface Tension.* **J. S. Stevens.** (Amer. Journ. Sci. 10. pp. 245–246, Sept., 1900.)—The method of measurement employed is as follows: An iron wire is bent into the form of a T and the cross allowed to float on the surface of water. The body of the T projects a little distance into the centre of a coil of copper wire through which a current may pass. The part of the T forming the plunger is adjusted so that its weight is nearly sufficient to break through the liquid surface. A slight pull towards the centre of the coil due to the passage of the current will then accomplish this. The system is raised and lowered by a rack and pinion so that it may be placed on the liquid surface as gently as possible. By means of a continuous resistance

the current may be applied in small increments. On the passage of the current the plunger moves to the centre of the coil and the pull is then steadily applied to the centre of inertia of the system. The magnetic force may be calibrated at leisure by use of a balance, or it may be calculated from the constants of the coil. This in proper units must be added to the weight of the system. J. J. S.

16. *Viscosity of Gases.* **Rayleigh.** (Roy. Soc., Proc. 67. pp. 187–189, Oct. 26, 1900.)—The author has tested this influence of variations of temperature upon the viscosity of helium, and has found that the temperature coefficient is the same as in hydrogen. The constant *c* in Sutherland's equation comes out as 72·2 for hydrogen and helium, and this value, together with those for air, oxygen, and argon, agrees well with the values calculated by Sutherland from Obermayer's observations. E. E. F.

17. *Surface Tensions of Liquefied Gases.* **L. Grunmach.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 38. pp. 829–838, July 26, 1900.)—Determinations by the method of capillary ripples of the surface tensions of liquefied SO_2, NH_3, chlorine and of "Pictet's Liquid" (SO_2 and CO_2 in molecular proportions). Results :—

Liquid.	Surface tension (in dyne/cm.'s).	Temp.
Sulphur dioxide	33·285	— 25° C.
Pictet's Liquid	35·065	— 38° C.
	38·209	— 60° C.
Ammonia	41·778	— 29° C.
Chlorine	33·6493	— 72° C.

The molecular weights of the three pure liquids were calculated from the formula $av^{\frac{2}{3}} = 2{\cdot}27(\theta - t)$ (Eötvös—Ramsay—Shields).

Only these single determinations were employed, and the critical temperatures (θ) were taken to be : 157° C. (SO_2), 130·5° C. (NH_3), and 145° C. (chlorine). The densities employed in the calculation were :—

Sulphur dioxide .... $d_{-25} = 1{\cdot}5016$
Ammonia .... $d_{-29} = 0{\cdot}6703$
Chlorine .... $d_{-72} = 1{\cdot}6452$

The molecular weights so calculated are as follows :—

Sulphur dioxide	65·66
Ammonia	17·10
Chlorine	92·14

According to these results, sulphur dioxide and ammonia are non-associating liquids while chlorine is associating. F. G. D.

18. *Sailing Birds Dependent on Wave-Power.* **L. Hargrave.** (Roy. Soc. N. S. Wales, Journ. & Proc. 33. pp. 125–128, 1900.)—From observations of sailing-birds following ships the theory is here advanced that they are supported by the upward air-current on the rising side or face of the wave. The following numerical case is given as an example of the feasibility of this theory of sailing motion. Let a sea-wave 180 feet long and 10 feet high travel at 18 knots, or say, 30 feet per second, under *calm* air. This wave will raise all the air as it passes 10 feet, at a mean rate of 3⅓ feet per second.

The rate will vary from zero in the trough, attaining its maximum velocity at half the wave height, or where the wave is steepest, and falling to zero at the crest. Let the maximum volocity of the uplift of the air be about 4 feet per second and the steepest part be of 10° slope. According to S. P. Langley, a plane surface 30 inches by 4·8 inches, weighing 1·1 lb., will glide on air, without losing its elevation, at a speed of 49·8 feet per second, if sloped 5°. That is, the plane pushes 4·33 feet of air vertically downwards whilst it is translated 49·8 feet in one second. The same effect with regard to the position of the plane at the end of its journey of one second's duration is produced if the plane be sloped 5° downwards, and the air through which it passes be pushed bodily upwards 4·33 feet in one second. Now the air over the wave under consideration is being lifted about 4 feet per second; so if the 1·1 lb. plane were launched with 5° downward slope in the same direction the wave is travelling, from one foot above the steepest part of the wave it would overrun the wave whose velocity is only 30 feet per second. It would thus get out of the air that is, being lifted and shoot into the water in the trough. But let the aspect of the plane be changed so that it faces 58° to the right or left of the track of the wave, then its position above mean sea-level and situation on the wave-slope will be unaltered; and, if the wave were of unlimited width the plane would continue its course till dashed ashore.

If the horizontal velocity of 49·8 feet per second be changed to a vertical one, it suffices to raise the plane to an elevation of 38 feet in a second and a half. And from a poise at this station a swoop down may be made in any direction till another place of uplifting air is found, in which its horizontal course may be resumed as before. E. H. B.

19. *Multiple Space in Applied Mathematics.* **H. S. Carslaw.** (Electrician, 45. p. 864, Sept. 28, 1900. Abstract of a paper read before the British Association.)—The ordinary method of images may be used in the solution of problems in electrostatics, &c., when the bounding planes meet at an angle π/m, but it fails when the angle of inclination is $n\pi/m$, n and m being positive integers. Sommerfeld has suggested that a Riemann surface might here be employed, and with the help of a multiple space, problems in electrostatics, electric conduction, hydrodynamics, sound, and conduction of heat, in which the boundaries are planes meeting at an angle $n\pi/m$ may now be solved by images. The author illustrates the process by the potential problem in which the boundary is the semi-infinite plane $\theta = 0$, and another in which the boundary is the infinite plane with hemispherical bowl. In the latter case the physical space is considered as given by $0 < \theta < 3\pi/2$, and three revolutions of the radius vector are required to complete the multiple space. The poles are at $(\pm\, \theta')$, $(\pm\, [3\pi + \theta'])$. E. E. F.

20. *Theory of Gravitation.* **R. A. Fessenden.** (Elect. World and Engineer, 36. pp. 478–479, Sept. 29, 1900.)—The present article is a short note claiming for its author an explanation of gravitation as a secondary electric effect. The full theory is to be published elsewhere. The hypothesis here put forward has been obtained in continuation of previous work on the nature of the electromagnetic quantities and the density and the elasticity of the ether [see Abstracts Nos. 1233, 1234, 1235, 1277, 1278, and 1279 (1900)], and is based partly on the author's own experimental researches and partly on those of other physicists. The chief results may be summarised as follows:—(1) "All simple dielectrics expand under electric stress. The expansion varies as the square of the electric intensity or voltivity, and

inversely as the elasticity." (2) When we place a dielectric in an electric field, we have a change in the density of the *substance*, and a change in the density of the *ether*. The former gives us Kerr's phenomenon, the latter changes the weight of the condenser. (3) The value of the electrostatic stress at the surface of a corpuscle is of the order 10^{20}, and the elasticity of the ether has been shown to be of the order 6×10^{20}. There is accordingly an enormous stress next the corpuscle, producing a change of density, the amount of this change varying inversely with the fourth power of the distance from the centre of the corpuscle and the total amount of expansion varying inversely as the square. But Newton showed that a change of density in the medium surrounding a particle of matter would account for the gravitational attraction. And the present method of accounting for this change of density gives an effect of approximately the right order. Thus—(4) "Inertia is an electromagnetic induction effect, due to the corpuscular charge. (5) Gravitation is a secondary effect, the electrostatic intensity due to the corpuscular charge causing a change of density in the ether surrounding it, this latter giving the gravitational attraction." Grounds are then adduced for holding that (6) "Gravitational force is propagated at practically infinite velocity as an expansional wave."

E. H. B.

21. *Action and Range of Molecular Forces.* **W. Müller-Erzbach.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 9–27, Jan.–March, 1900.)—In continuation of the investigation referred to in Abstract No. 774 (1899) the diffusive action of CS_2 through gum-covered paper, collodion, &c., into free air is observed, and then the effect of slabs of fir, sealing-wax, beeswax, and indiarubber (which easily absorb CS_2) is examined when they are immersed in CS_2 with one ~~face~~ protected by impermeable glass, and the other covered by these permeable coatings; and it is found that in the latter case the rate of passage of CS_2 through these coatings is much (even over ten times) greater than in the former. The author's chief conclusions are that (i) CS_2 penetrates by free diffusion into colloidal bodies to only small depths, (ii) when by free diffusion CS_2 has reached an attracting body, its flow becomes perceptible though before not observable, (iii) different attracting bodies have different attractive actions on CS_2, beeswax attracting less than either fir or indiarubber, (iv) the attractive effect is perceptible through a distance of at least 0·066 mm.

R. E. B.

22. *Motion of a Sphere in a Viscous Fluid.* **H. S. Allen.** (Phil. Mag. 50. pp. 323–338, Sept., and pp. 519–536, Nov., 1900.)—This paper describes an experimental investigation of the rate of motion of bubbles of gas in rising through a viscous liquid. A bubble of air is liberated from a fine capillary tube at the bottom of a long glass vessel containing the viscous liquid, and the time taken for the bubble to rise through certain heights is measured. The bubble is caught under a small glass vessel before it reaches the surface, and its diameter is then measured by means of a microscope. All the data are thus obtained for determining the connection between the limiting uniform velocities of the bubbles and their diameters. The object of the investigation was to see whether this connection conforms with the theoretical one for the motion of a solid sphere. According to the theory, Va must be small compared with ν, the kinematic coefficient of viscosity, in order that the motion be non-eddying, a being the radius. If this condition is fulfilled, then the velocity varies as the square of the radius. If, however, the motion is eddying, a study of the dimensional equation shows that the velocity is proportional to

$$a^{\frac{3}{n}-1} \Big/ \nu^{\frac{2}{n}-1}$$

if we assume that the resistance is proportional to V^n.

In order that the motion may be non-eddying, the radius a, when water is used, must be very small, so small that it approaches the lowest practical limit of size of the bubble. The experiments with water are therefore all on eddying motion. The curve obtained by plotting V with a as abscissæ is a straight line, so that the resistance must therefore be proportional to $V^{3/2}$. By using aniline the critical radius is increased greatly, and the experimental results with this liquid show that with the smallest bubbles $V \propto a^2$ so long as the motion is non-eddying, and $V \propto a$ in the case of eddying motion. Experiments were also made with paraffin and amber spheres.

The terminal velocity acquired in the case of eddying motion is given by the following formula :—

$$V = k\left(\frac{\overline{\rho-\sigma}\,.\,g}{\rho}\right)^{\frac{2}{3}} \frac{a-ha'}{\nu^{1/3}}, \tag{1}$$

where the value of the constant k is nearly $\frac{1}{2}$ and of h nearly $\frac{2}{5}$, a' being the critical radius given by $Va' = \nu$, ρ being the density of the liquid and σ that of the sphere.

In the second part of the paper the experiments are extended to the case of a body whose terminal velocity in falling through the liquid is great. Steel balls of various diameters (0·3 to 0·8 cm.) are allowed to fall through water, the ball being liberated under the surface of the water. The velocity of the ball is determined by a photographic method, the ball being instantaneously photographed at equal intervals of time on the same plate, the plate being moved laterally between two exposures, so that a fresh strip is exposed for each photograph.

In every case, except that of the largest ball, the terminal velocity agrees with the law of resistance

$$R = k\rho a^2 V^2,$$

where a is the radius of the sphere and ρ the density. The discrepancy in the case of the largest ball is attributable to the influence of the sides of the vessel, since by increasing the size of the vessel the discrepancy is greatly diminished. All the terminal velocities are over 80 cm./sec. (83 to 128 cm./sec.), and the rate at which the acceleration falls off was observed to increase suddenly when the velocity was about 75 cm./sec. This seemed to show that the law of resistance to the *steady* motion of the sphere undergoes a sudden change at this particular velocity.

The terminal velocity is given by

$$V^2 = \frac{1}{k} \cdot \frac{4}{3} \pi g \frac{\sigma - \rho}{\rho} a, \tag{2}$$

where σ and ρ are the densities of the ball and liquid respectively. The mean value of k is $5{\cdot}50 \times 10^{-4}$.

The conclusions derived from all the experiments are as follows :—

(1) When the velocity is sufficiently small the motion agrees with that deduced theoretically by Stokes for non-sinuous motion, on the assumption that no slipping occurs at the boundary. In such motion the resistance is proportional to the velocity.

(2) When the velocity is greater than a definite critical value the terminal velocity of small bubbles and solid spheres is proportional to the radius less a small constant; it may be expressed by the formula (1), which indicates a resistance varying as the velocity raised to the power three halves.

(3) For velocities considerably greater than those just considered the law of resistance is that which Newton deduced from his experiments, namely, that the resistance is proportional to the square of the velocity. J. B. H.

23. *Graphical Treatment of Experimental Curves.* **R. A. Lehfeldt.** (Zeitschr. Phys. Chem. 35. pp. 96-97, Oct. 5, 1900.)—The author has had occasion to integrate an expression of the form—

$$z = \int \phi(x) f'(x)\, dx,$$

where $f(x)$ is given by an experimental curve. By partial integration he obtains

$$z = [\phi(x) f(x)] - \int \phi'(x) f(x)\, dx,$$

an expression which can be dealt with graphically, since all the factors in it are known. J. B. H.

24. *Rainfall, Character of Seasons, and Drought Curves.* **H. Deane.** (Roy. Soc. N. S. Wales, Journ. & Proc. 33. pp. 63-68, 1900.)—As the usual methods of plotting rainfall do not give any information concerning the conditions of the soil, the author proposes a new way of plotting drought curves. The upper line is the soil saturation curve. The drought line underneath it represents the amount of rain (in tenths of an inch) required to restore saturation for that day. Any excess of rain over that saturation could not be plotted, but only be entered in figures. Evaporation begins with cessation of the rainfall, and it will depend upon temperature, wind, &c. The average monthly rates of evaporation from water have been tabulated by H. C. Russell. The author takes half these rates as the "rates at which evaporation from the soil would probably begin." The diagrams given by the author are based upon his own rainfall record for the Paramatta River district, covering the years 1883 to 1899. H. B.

25. *Determination of Drought Intensity.* **G. H. Knibbs.** (Roy. Soc. N. S. Wales, Journ. & Proc. 33. pp. 69-85, 1900.)—Observations, partly mathematical, on the preceding paper. The real condition of the soil will depend upon a great many factors, independent of one another; upon the quantity and rate of rainfall; slope, relative saturation and permeability of the soil; percolation through it, when interstices are filled or not filled with water; temperature, solar radiation, humidity, diffusion of vapour, wind, deposition of dew; further, upon the mechanical effects of frost, and finally upon biological factors, vegetation, &c., which we cannot express mathematically at all. Yet the possible observations would be of great service for estimating the drought intensity. H. B.

26. *Heat and Thunderstorm after Dark.* **H. C. Kiddle.** (Roy. Soc. N. S. Wales, Journ. & Proc. 33. pp. 204-206, 1900.)—Observed at Seven Oaks, on the Macleay River, N. S. Wales, seven miles from the sea. Hot weather had prevailed for several days, the maximum being reached already at 10 a.m., the heat being as strong at 7.30 a.m. as at noon; a north-easterly breeze from the sea then cooled the air. The maximum reading of November 27, 1899, about

10 a.m. was 91·8°; at 7 p.m. it was 75°. Lightning without rain then approached from W.N.W. with a hot wave; in a few minutes the temperature rose to 86°; at 8.15 p.m., when the disturbance had passed, it was 95·5°. H. B.

27. *Hydrogen and Hydrocarbons in the Atmosphere.* **A. Gautier.** (Revue Scientif. 14. pp. 389–399, Sept. 29, 1900, Comptes Rendus, 131. pp. 647–652, Oct. 22, 1900. Paper read before the International Congress of Pure Chemistry.)—The author describes his combustion apparatus for determining the combustible gases, essentially H_2 and CH_4, in the atmosphere. The determination is very difficult because at the high dilution of these gases, with up to 20,000 times their volumes of air, the combustion of hydrogen is never complete, and the carbon burns at a slower rate than the hydrogen. As both gases are determined together, their percentages can only be estimated statistically from the proportions of the resulting H_2O and CO_2. From many experiments, often lasting twenty-four hours each, conducted in Paris, in an oak forest, in a desolate part of the Pyrenees at an altitude of 2,785 m., and on a rock 40 km. from the north coast of Brittany, the author concludes that the purest (ocean) air contains normally about 20 cc. of H_2 in 100 litres, *i.e.*, two parts in 10,000. The hydrocarbons, estimated as CH_4, amount to 22·6 cc. (in 100 l.) in Paris, 11·3 in the forest, 2·19 in the mountains, and zero out at sea. Further experiments yield for the Paris air: 19·4 cc. of H_2 (in 100 l.), 12 of CH_4, 1·7 of benzene and homologues, 0·2 of CO. Hydrogen exhalations are common in volcanic districts, and methane is exhaled by the soil. By decomposing granite with water at 300° C. or with diluted phosphoric acid at 150° C., the author found large volumes of hydrogen in the gases liberated, up to 400 cc. per kg. of granite in the latter case. It is not necessary, however, to assume the penetration of superficial water down to the igneous regions of the interior. The decomposition with water of iron nitride, occurring in the Etna lava, would also yield hydrogen, and the decomposition of certain carbides, such as Al_4C_3, would give methane. H. B.

28. *Apparatus for Recording Direction of Wind.* **W. Volkmann.** (Zeitschr. Instrumentenk. 20. pp. 237–239, Aug., 1900.)—At the Agricultural College of Berlin the apparatus registers eight wind directions with the aid of two styles. The electrical arrangements are of the Sprung type and combined with a Fuess vane. The current distributor is a platinum sector of 135°, turning about its vertical axis over four contacts, joined to two pairs of electromagnets, arranged in the same horizontal plane. In front of each pair swings an iron pendulum, to which a style is attached, and the two styles draw zigzag curves on a paper tape. Deflections of the pendulums to the left signify wind from the N. and E. respectively; to the right, S. and W.; the simultaneous play of the pendulums indicates N.E., &c. As continuous records are not desired, the return wire is taken to a relay, which is excited every three minutes by a clock which also pulls the tape down; thus twenty records are obtained every hour. The apparatus works with weak currents of 0·01 ampere. The platinum sector is not exposed to shocks, nor does it impede the vane. The gearing is not explained. H. B.

29. *Hail Showers and Cannonades.* **J. Sigaux.** (Revue Scientif. 14. pp. 461–464, Oct. 13, 1900.)—The first congress concerning the dispersion of hail showers by cannonades was held at Casale in 1899. At present Italy is supposed to have 16,000 hail stations, chiefly for the protection of vineyards. At Denicé, in the Beaujolais district, fifty-two steel guns of the Vermorel type

mounted perpendicularly are used for this purpose. The storms approach almost always from the south-west, and the guns furthest out in that direction are discharged first, twice every minute, if possible, during the first minutes; the cannonade is continued even when hail falls until the storm has dispersed. The Government grants the powder at a reduced price. The author discusses the costs of such installations. The effect might depend upon the column of hot air blown upwards from the gun. H. B.

30. *Meteorological Kite-Flying.* **S. P. Fergusson.** (Science, 12. pp. 521–528, Oct. 5, 1900.)—The greatest height reached at the Blue Hill Observatory with a kite attached to a No. 17 steel pianoforte wire on July 19, 1900, was 4,850 m. The original Hargrave kites attained an angular altitude of 54° or 56°; the maximum angle is now 66°, and the downward pressure of the wind on the upper edges of the cells is not strong, as long as the wind velocity does not exceed 20 m. per second. Such steep kites are, however, unstable, and a slight pull on the line may bring them beyond the zenith. Thin wires are on the whole preferable to stout wires, but for the highest angular altitudes the stouter wires are safer, in spite of their greater weights. The reason is that the pressure of the wind on the wire is an essential factor; this pressure depends upon the surface, which increases less rapidly with increasing diameter than the weight. As a rule, six kites, three large and three small ones, of a total lifting surface of 80 sq. m., are employed at one time; for eight kites, No. 25 or 26 wire would be best suited. H. B.

31. *Annual Variation of Temperature at Melbourne.* **R. J. A. Barnard.** (Phil. Mag. 50. pp. 408–409, Oct., 1900.)—The author has analysed the temperature observations, extending over forty years, after Rijkevorsel's method. The forty years were divided into two groups, 1859–78, and 1879–98. In each group the average for each day is obtained and modified by replacing the temperature of each day by the mean of the five consecutive days of which the particular day is the centre. The results are plotted as curves. Some striking resemblances are noticeable, especially at the end of March. The temperature begins to drop rapidly in the second week of March, the secondary minimum in each group on the 19th being followed by a maximum on the 25th and 26th. But on the whole the spells of weather do not appear to be so well marked as in Europe, owing probably to the more uniform conditions of the southern hemisphere. The author regards the method as valuable, but would not draw any conclusions from periods of less than forty years with groups of twenty years. H. B.

32. *New Theory of the Milky Way.* **C. Easton.** (Astrophys. Journ. 12. pp. 136–158, Sept., 1900.)—Previous investigations by the author had indicated that the Milky Way had a roughly annular structure (Astrophys. Journ. 1. pp. 216–221, March, 1895). Seeliger, however, thinks that the stellar accumulations in the galaxy in different directions are probably at different distances. In the present paper the author renounces the "annular" theory and proposes a new conformation in its place. He first draws attention to the marked difference in brightness of the galaxy at the two diametrically opposite regions of VI and XVIII hours of right ascension respectively.

Gauges by Herschel, Celoria, and Houzeau give decisive evidence of the preponderance of bright regions in the zone near Aquila (XVIII h. RA.), and indicate that our solar system is probably *eccentrically* situated with respect to the galaxy. Exhaustive discussion follows of the many different peculiarities, and finally it is proposed that the Milky Way be regarded as a special nebula of somewhat advanced development, the central condensation of which consists of the abnormal bright region near β and γ Cygni. Our solar system and possibly many of the brighter stars would constitute another smaller condensation away from the centre, and the various sections through the different spirals in all directions might serve to account for most of the appearances actually seen. C. P. B.

33. *Solar Phenomena and Anomalous Dispersion.* **W. H. Julius.** (Astrophys. Journ. 12. pp. 185–200, Oct., 1900. From the Roy. Acad. Sci. Amsterdam, Proc.)—The author considers the application of the phenomena of anomalous dispersion as determined by Becquerel in the case of the sodium (D) lines to the theory of Schmidt regarding the visible photosphere of the sun as an optical phenomenon produced by the curved refractions of the sun's atmosphere. In the actual experiment with sodium he describes an additional appearance to that figured by Becquerel, whose diagram would indicate that light was wanting in the region of the D lines themselves, but in the figures here given it is seen that this is only caused by the great lateral displacement of the distorted lines.

The chief inference from such data is that when light is emitted by a source yielding a continuous spectrum, and then traverses a space containing, for example, unequally distributed sodium vapours, the rays near the D lines will be more deflected than any others from their normal courses. The well-known "arrow-head" appearance of the bright chromospheric lines when observed with radial slit may be explained in this way. The characteristic phenomena connected with sunspots, spectra, the reversing layer and "flash' spectrum, and the displacement of the latter with respect to the Fraunhofer lines are also considered. C. P. B.

34. *Actinometry during Partial Solar Eclipse.* **S. R. Bennett.** (Roy. Dublin Soc., Proc. 9. pp. 365–376, Oct. 17, 1900.)—The chemical effect of the variation in the solar radiation during the eclipse of May 28, 1900, was measured by means of an actinometer depending on the change of tint of sensitised paper. Curves are given showing the observations made.

C. P. B.

35. *Temperature during Partial Solar Eclipse.* **C. Martin.** (Roy. Dublin Soc., Proc. 9. pp. 362–364, Oct. 17, 1900.)—This paper gives results obtained at the Dunsink Observatory during the partial eclipse of the sun on May 28, 1900. Two heat radiation thermometers were used, with white and black bulb respectively. These were mounted about 1 inch apart on a post 6 feet high, with the bulbs pointed directly to the sun. Curves are given showing the variations, from which it is seen that the temperature was at its lowest about ten minutes after mid eclipse. With the black bulb the highest reading was 63·7°, the lowest 35·7°, showing a fall of 28°; while with the white bulb the corresponding readings were 15·6° and 8°, showing a fall of 12·6°. C. P. B.

36. *Detection of Corona without an Eclipse.* **H. Deslandres.** (Comptes Rendus, 131. pp. 658–661, Oct. 22, 1900.)—The author describes his work during the recent total solar eclipse in May, 1900, when he states that he found distinct evidence of the special radiation of the corona by investigation of the infra-red region of the spectrum. Since the eclipse he has set up an

instrument at the Meudon Observatory, near Paris, with which he considers positive results have been obtained. The image of the sun is produced by a mirror of 0·80 metre aperture and 1·50 m. focus. The light from this is analysed by a slit spectroscope with crown prism. A Melloni or Rubens thermopile and Deprez-d'Arsonval galvanometer are then used to detect any radiation passing through the apparatus. He finds that at all hours of the day the sum of the deviations measured along the solar equator are greater than the sum of the corresponding deviations along a polar diameter. This would indicate that the difference was due to the radiation of the corona, and is in accordance with the present disposition of the coronal streamers at sunspot minimum—great equatorial extensions and small polar plumes.

C. P. B.

37. *Kinetic Theory of Planetary Atmospheres.* **G. H. Bryan.** (Roy. Soc., Proc. 66. pp. 335–336, June 9, 1900.)—After citing previous work by Waterson and Stoney [Abstracts Nos. 1025 (1898) and 1988 (1900] the author investigates the conclusions obtained by applying the Boltzmann-Maxwell distribution to the atmospheres of planets. The advance on work done in 1898 consists in the consideration of the effects of axial rotation of the planets, the surfaces of equal density then becoming of the form originally suggested by Roche. These cease to be closed surfaces when passing to the outside of the point on the equatorial plane, where the centrifugal force just balances planetary attraction. The author calls the surface through this point the "*critical surface,*" and the ratio of density at planet's surface to the density at this critical surface, the "*critical density ratio.*" He then calculates the logarithm of this quantity for particular gases at different temperatures on the various planets. Next the rate of flow outwards from this surface is determined, and instances cited of the values deduced for helium, hydrogen, and water-vapour, which would appear to indicate that helium cannot escape from the earth's atmosphere at existing temperatures, nor water-vapour from the atmosphere of Mars. C. P. B.

REFERENCES.

38. *Experiment on Gas Pressure.* **C. Forch.** (Phys. Zeitschr. 1. pp. 574–575, Sept. 15, 1900.)—A lecture experiment modified from one of Warburg's so as to allow any gas to be used, the object being to show the dependence of gaseous pressure on the height and density of the gas column. G. E. A.

39. *Crystal-Elasticity.* **W. Voigt.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 2. pp. 117–176, 1900. Referat f. d. internationalen phys. Congress in Paris.)—An account of the present-day state of our knowledge of crystal-elasticity.

T. H. P.

40. *Testing of Aneroids.* **P. Hebe.** (Zeitschr. Instrumentenk. 20. pp. 253–266, Sept., 1900.)—Paper on the methods adopted at the Charlottenburg Imperial Physico-Technical Institute during the past ten years. A. D.

41. *Magnetic Influence of Sun on Earth and Comets.* **A. Harvey.** (Canadian Inst. Toronto, Trans. 6. pp. 345–358, 1899.)—The paper is a discussion of the simultaneous occurrence of outbursts of spots on the sun, magnetic disturbances and auroræ on the earth, and peculiarities in the features of comets. The probability of the suggested close connection is supported by the curves given from automatic records of the horizontal force at times when specially prominent spots were existent. C. P .B

LIGHT.

42. *Velocity of Light.* **Perrotin.** (Comptes Rendus, 131. pp. 731–734, Nov. 5, 1900.)—Operations have been commenced at the Observatory of Nice in view of a new determination of the velocity of light. The method adopted is that of the toothed wheel of Fizeau as modified by Cornu. The results of the preliminary observations between two stations nearly 12 kilometres apart are here given. The value found is 299·90 ± 0·08 for the velocity *in vacuo* expressed in thousands of kilometres. This number results from about 1,500 measurements extending over a year, the observers having made use only of images absolutely still, and taken the observations at leisure and without precipitation, with the object of attenuating or eliminating systematic errors, especially those of a physiological order. The source of light was the filament of an electric lamp of 16 candle-power.

J. J. S.

43. *Abnormal Wave-Velocity near a Focus.* **P. Zeeman.** (Phys. Zeitschr. 1. pp. 542–543, Sept. 1, 1900.)—Gouy has shown that when monochromatic light passes through a focus or a focal line its path appears to be shortened by a half wave-length or a quarter wave-length respectively. The present paper shows that this is due to an increase of velocity of propagation near the focus. The mathematical theory establishing this begins with Hertz's electromagnetic doublet, and treats it by the Hertz-Heaviside equations. It is thus derived that the *phase-velocity* is infinite at the doublet, and falls to the usual speed of light at distances from it which are great compared with the wave-length. An experimental demonstration of the abnormal speed is then described. It consists essentially of a plano-convex lens of calcspar, with its optical axis in the plane face, placed between two Nicol prisms. All are mounted on an optical bank, illuminated, and the resulting system of interference rings observed. On exploring in the neighbourhood of the foci for ordinary and extraordinary rays, the evidence of the abnormal velocity can be observed.

E. H. B.

44. *Rangefinders.* **W. Stroud.** (Nature, 62. pp. 607–609, Oct. 18, 1900. Paper read before the British Association.)—This paper contains a synopsis of a lecture on Rangefinding delivered at the British Association meeting at Bradford. After dealing with the general principles of rangefinding, the author shows how the operation of finding the range, which is comparatively easy on land when length of base and time are not restricted, becomes at sea a most interesting and difficult scientific problem owing to the limitation of both base and time. He then describes four instruments, all of which are used, or promise to be used, for warlike purposes. These are: (1) The Watkin Mekometer, which is used by infantry. (2) The Watkin Depression Rangefinder, used at certain stations for coast defence. (3) The Grousillier-Zeiss Rangefinder. (4) The Barr and Stroud Rangefinder, used in the British and other navies, in coast fortifications, and to some extent in the field.

The mekometer is a long-base two-observer rangefinder, one observer carrying a box sextant and the other an optical square, the two observers being kept at a constant distance apart by a cord between them. The Depression Rangefinder consists of an instrument of the type of a surveyor's level, which is used for measuring the depression of a ship's water-line below the horizontal plane through the observing station, which is generally a fortress on a hill near the coast. A correction has, of course, to be made for the height of the tide. The Grousillier-Zeiss Rangefinder has already been described in these pages [Abstract No. 1396 (1900)]. The Barr and Stroud Rangefinder is not described in the paper, but the reader is referred to the Transactions of the Institute of Mechanical Engineers, 1896, or to *Engineering*, 1896, vol. i. p. 233. Illustrations of the Barr and Stroud Naval, Fortress and Field rangefinders, and of the fields of view of the Grousillier-Zeiss instrument are given. J. B. H.

45. *Illumination of Objects under the Microscope.* **R. W. Wood.** (Phil. Mag. 50. pp. 347–349, Sept., 1900. Paper read before the Physical Society of London.)—Toepler's "Schleieren-Methode" is here used to render visible under the microscope the separation of two bodies of nearly equal refractive index, the one immersed in the other, as, for instance, glass particles immersed in cedar oil, or the different crystals in a rock section. A low-power objective is used in the microscope, and a short focus lens is placed under the stage so as to form an image of the lamp (placed a few feet away) at a point between the object to be examined and the objective. A screen bounded by a straight edge is placed in front of the flame so as to cut off half the flame. At the image of this screen formed in front of the objective by the short focus lens, a small straight edge is interposed with its edge parallel to the straight edge of the image of the screen, and in such a position as to cut off all the light except a very fine slit between the two edges.

Two photographs are shown of glass particles in cedar oil, one taken with ordinary illumination and the other with the above arrangement. The difference is very marked. J. B. H.

46. *Index of Refraction and Dispersion of Bromine.* **C. Rivière.** (Comptes Rendus, 131. pp. 671–672, Oct. 22, 1900.)—The index of refraction of bromine for wave-lengths ranging from 790·9 to 539 was determined at 10°, 15°, 20°, and 25°; the results are given in tabular form. The dispersion is unusually high, the value 0·037 being found at 20° between the A and D lines. N. L.

47. *Dispersion of Iceland Spar.* **E. Carvallo.** (Journ. de Physique, 9. pp. 465–479, Sept., 1900.)—The author has made a new experimental study of the dispersion of Iceland spar in the ultra-violet. It is more precise than former observations. On joining with it the one made formerly in the infra-red and the visible portion, a series is furnished the precision of which attains the fifth decimal figure of the index throughout the whole extent of the spectrum.

The author has calculated for the extraordinary ray two formulæ of dispersion with five terms—

$$\text{(I)} \qquad \frac{1}{n^2} = c'l^4 + cl^2 + a + bl^{-2} + b'l^{-4},$$

$$\text{(II)} \qquad n^2 = C'\lambda^4 + C\lambda^2 + A + \frac{b_1}{\lambda^2 - \lambda_1^2},$$

Where n represents the index of refraction; λ the wave-length *in vacuo;* and $l = \frac{\lambda}{n}$, the wave-length in the body studied for the same radiation. Both formulæ represent the observations satisfactorily. For the ordinary ray neither of these two formulæ with five coefficients is sufficient, but the first agrees more nearly with the facts than the second.

It is necessary to add a term in l^{-6} to formula (I) in order to represent the dispersion throughout the whole extent of the spectrum. The author has calculated the formula with six coefficients—

$$\frac{1}{n^2} = c'l^4 + cl^2 + a + bl^{-2} + b'l^{-4} + b''l^{-6}.$$

This also proved satisfactory.

In formula (II) it is necessary to take not only one fraction but two fractions—

$$\frac{b_1}{\lambda^2 - \lambda_1^2} + \frac{b_2}{\lambda^2 - \lambda_2^2}$$

For the ray Cd_{26} ($\lambda = 0{\cdot}214439\mu$), the term bl^{-2} is $-0{\cdot}044157$ for the extraordinary ray and 0·074016 for the ordinary ray. Consequently the success of the comparison of formula (I) with the observed numbers requires that more than four figures be known in the value of λ. The present work proves that the numbers determined by Kayser and Runge satisfy this condition. Their agreement with the numbers of Eder and Valenta tends to the conclusion that the fifth figure is exact. J. J. S.

48. *Colour Photography.* **E. S. Shepherd.** (Soc. Arts, Journ. 48. pp. 758–766, Aug. 31; 769–776, Sept. 7; 781–788, Sept. 14; and 793–797, Sept. 21, 1900. Cantor Lecture.)—Lecture I. is a popular demonstration of the principal optical phenomena.

Lecture II. treats of the spectrum, and the preparation of orthochromatic photographic plates. The construction and testing of the Cadett lights filters is described at length; these are for use with the Cadett Lightning spectrum plate, and are made in two types, the "Absolutus" and the "Gilvus." The former reduces the action of the blue so as to allow the reds and greens to impress the plate correctly, and requires an increase of exposure of about forty times; the latter increases it only five times, but leaves the reds uncorrected.

Lecture III. is occupied with a detailed description of the three-colour process of producing transparencies or prints in natural colours, and Lecture IV. treats of typographic reproduction. G. H. B.

49. *Testing Photographic Shutters.* **R. Nerrlich.** (Zeitschr. Instrumentenk. 20. pp. 269–275, Sept., 1900.)—Apparatus and methods are described. A simple drop shutter with circular aperture gives an effective exposure equivalent to an actual exposure with full aperture equal to 0·48 × the time of passing of the aperture. A Goerz sector shutter working at $\frac{1}{150}$ second gives an exposure equivalent to $\frac{1}{250}$ second full aperture; at $\frac{1}{2}$ second it gives very nearly the full value. A focal plane shutter gives very nearly the full instantaneous value of equivalent exposure; but the speeds are not uniform throughout. A. D.

50. *Flame Measurer for Hefner Lamp.* **F. F. Martens.** (Deutsch. Phys. Gesell., Verh. 2. 10. pp. 108–109, 1900.)—This is a contrivance for easily measuring the height of the flame of a Hefner standard lamp. It consists of a rectangular glass prism, the hypotenuse of which has been given a spherical form, so that the whole acts like a cemented combination of a prism and plano-convex lens. When this is held near a light source, an inverted image of the source is formed near the original, and the distance between the bases of the flame and its image when the tips apparently coincide will be double the required height. C. P. B.

51. *Photometry.* **J. Violle.** (Écl. Électr. **24.** pp. 420–431, Sept. 15, 1900. Paper read at the Paris International Electrical Congress. An Abstract of this appeared in the Electrician, Sept. 28, 1900.)—This paper gives an account of the various photometric standards.

I. *Incandescence Standards.* (1) The platinum international standard gives satisfactory results provided the materials used are pure. Petavel gives the preference to the Violle standard, used under the following conditions :—

(*a*) The platinum must be chemically pure.
(*b*) The crucible must be made of pure lime.
(*c*) The hydrogen burnt must not contain hydrocarbons.
(*d*) The gases should be in the proportion of 4 volumes of hydrogen to 3 of oxygen.

The best mixture is obtained by sending the oxygen at the same time through an interior tube and through an annular conduit exterior to the hydrogen conduit. Under these conditions the platinum is raised to a temperature little higher than that of fusion and the brightness of the metal is not modified by a combination with carbon.

The following table gives the variation of the luminous intensity with the time expressed in seconds measured from the moment of stopping the arrival of the gases :—

Time.	Intensity.	Time.	Intensity.
10	2·236	90	1·001
20	1·503	100	0·993
30	1·196	110	0·991
40	0·908	120	0·988
50	0·693	130	0·986
60	0·623	140	0·984
70	0·559	150	0·897
80	1·008	160	0·722

The intensity falls at first very rapidly, then rises suddenly (when solidification occurs), and for the next 40 or 50 seconds varies very slowly, then the diminution becomes more rapid. It is considered that the uncertainty relatively to the intensity of the light emitted by the melted platinum under normal conditions does not exceed 1 per cent.

(2) Lummer and Kurlbaum have proposed to employ incandescent platinum at a lower temperature than that of fusion and defined by the condition that $\frac{9}{10}$ of the energy radiated should be absorbed by a layer of water 2 cm. thick ; but the most serious objection to this is that the temperature chosen is too low and the light emitted is too red. This arrangement might, however, be used as an intermediate standard.

(3) Experiments have been made with a view to taking the crater of the positive carbon in the electric arc as a standard. A difficulty in this case arises from the fact that when the arc hisses the most brilliant part displaces itself periodically over the surface of the carbon. Entirely satisfactory results have not yet been obtained.

(4) Incandescence lamps have been introduced as intermediate standards in photometry. In order that the luminous intensity may be constant, very precise regulation of the potential at the terminals is necessary. When the

mean of the intensities in three directions is taken for the horizontal intensity, the mean error is about 2 per cent.

II. *Flame Standards.* (1) The Hefner standard, which uses amyl acetate and requires very careful regulation of the height of the flame, is the legal standard in Germany. Liebenthal has shown that its intensity is on the average many hundredths greater in winter than in summer. This effect is due principally to the presence of water-vapour. The influence of external pressure is feeble. The effect of carbonic acid is for equal volumes much greater than that of water-vapour. The diminution of the proportion of oxygen in the air after the lamp has been burning some time also affects it. Making corrections for these influences the Hefner standard becomes perfectly comparable with itself. Even then it cannot be considered perfect. The red tint of the flame and its feeble luminous intensity are grave faults.

(2) In the pentane standard of one candle, the liquid pentane contained in the receiver vaporises itself by a wick placed in the interior of a tube, which extends beyond it some centimetres. The vapours are inflamed on going out from the tube in such a way that the wick is not carbonised. The upper part of the flame is surrounded by a chimney which diminshes its mobility, and making combustion more active, renders the flame whiter. The height of the flame must be kept constant. The intensity of the visible part between the burner and the base of the chimney is then equal to an English candle.

In the lamp of ten candles, which is the regulation pattern for gas trials in England, the lamp is fed by a current of air charged with pentane vapour in its passage across a saturator; the mixture descends under the action of its own weight by a caoutchouc tube into an annular burner of steatite; the chimney is surrounded by a tube of brass in which is produced an ascending current of air led to the base of the ring of steatite. The height of the visible part of the flame must be 47 mm. According to Vernon-Harcourt, the ratio of the two standards does not vary by 1 per cent.

Liebenthal, on examining the one-candle pentane standard, finds that exact regulation of the flame is necessary, and that observations must not be made till the end of half an hour, as during this time the flame increases in height. Calculation shows that the efficacious distance in photometric measurements with such a lamp is that from the photometer to the axis of the lamp, diminished by half the radius of the tubes which limit the efficacious part of the flame. This lamp excels the Hefner lamp in having a more vigorous flame, but requires more attentive regulation. The influence of humidity is the same as in the Hefner lamp. It is affected by pressure: a change of 40 mm. produces a variation of 2 per cent. Liebenthal concludes that it is necessary with this standard to take into account the altitude of the place of observation. This appears to be the gravest fault of the pentane lamp and is considered to establish the superiority of the Hefner lamp as compared with it.

(3) The apparatus of Dibdin, which had been recommended by the Report of the Photometric Committee, was studied by Grafton. In it the air is carburetted by passing over pentane in a reservoir, which forms the base of the apparatus, and the proportion of air and of pentane depends on the temperature of the room. The degree of humidity must also have a great influence. In the Methven standard, on the other hand, with a diaphragmed flame, carburetted with pentane and fed by ordinary illuminating gas, very good results have been obtained. Humidity and temperature appear not to produce variations greater than 0·5 per cent., but this figure should not be accepted without reserve.

(4) Various flame standards have been lately proposed, which have not yet been adopted in practice. These are principally acetylene standards. The acetylene flame has a remarkable whiteness; the spectrophotometric study has shown that over the whole extent of the visible spectrum the light from acetylene differs little from that given out by melted platinum.

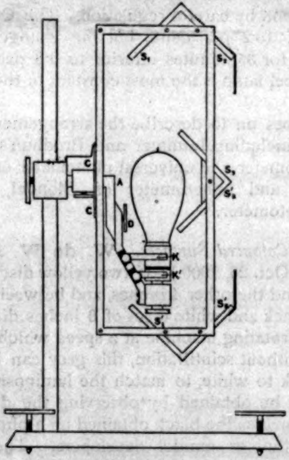
(5) A bolometric study by Clayton, Sharp, and Turnbull, has revealed the existence of unexpectedly large variations in the total emission of the different standards. In the English candle the variations may attain 46·5 per cent. of the mean intensity; the maximum variation for the German candle is 24 per cent. The variations of the Hefner standard may reach 22·6 per cent., but they are mostly due to changes of the height of the flame and may be reduced to 2 per cent. by careful regulation. The Carcel lamp may have extreme variations of 18·2 per cent., but the changes are slow and the variation may remain for 35 minutes inferior to 0·8 per cent. The authors conclude that the Carcel lamp is the most constant of the standards they have examined.

The paper next goes on to describe the arrangements of various recent forms of photometer, including Lummer and Brodhun's improved modification of Bunsen's photometer, the universal photometer of Blondel and Broca, the photomesometer and lumen-meter of Blondel, and Lummer and Brodhun's spectrophotometer. J. J. S.

52. *Luminosity of Coloured Surfaces.* **W. de W. Abney.** (Roy. Soc., Proc. 67. pp. 118–122, Oct. 26, 1900.)—If two yellow discs are taken, one (say) 8 inches in diameter and the other 4 inches, and between them is sandwiched a pair of interlaced black and white discs of 6 inches diameter, and the four discs are rotated on a rotating machine at a speed which will make the black and white into grey without scintillation, this grey can be made, by altering the proportion of black to white, to match the luminosity of the yellow. A very exact match can be obtained by observing the discs through a black transparent medium, such as the black obtained on a photographic plate after development with methol or amidol developers. The deposit may be so dense that the yellow colour may practically disappear, and the two dull greys may then be readily matched. The luminosity of the yellow in terms of the white is given by the angle which the white subtends when the small proportion of white reflected from the black annulus is added to it. The same procedure may be adopted for a green colour and its luminosity be obtained. When the luminosities of these two colours have been determined, 4-inch discs of them may be interlaced with blue, and a grey formed which can be matched with a grey formed of black and white as before. From the angles which the sectors of the colours subtend and of the black and white employed, the luminosity of the blue can be calculated. The luminosity of the blue being ascertained, a red disc may be interlaced with the green and the blue disc, and that of the red calculated. As a check a black and yellow disc may be interlaced and compared with the colour given with the red and green discs interlaced, one of the pairs being of greater diameter than the other.

Having obtained the luminosity of the three standard colours, that of any other colour can be calculated by substituting for one of them a disc of such colour, and again making a grey and matching it with a grey formed by the black and white. This method can be carried out in any light, but the luminosities of the colours will vary according to the quality and kind of light employed. J. J. S.

53. *Glow Lamp Support for Photometers.* **C. H. Sharp.** (Phys. Rev. 11. pp. 181–187, Sept. 1900.)—This support is designed for the determination of the mean spherical candle-power of a glow lamp from a few measurements. The lamp is supported with its axis vertical and is rotated about this axis. The lamp is not viewed directly, but after triple reflections in the mirrors S_1, S_2 and S_3, also S'_1, S'_2, S'_3. The frame carrying these mirrors can be rotated about the axis A, through an angle which may be read off on the scale C. By plotting the polar curve of c.p. for values from 0° to 90°, and determining the mean radius vector, the mean spherical c.p. is obtained. The author finds that four readings in positions differing by 30° are quite sufficient, and he has obtained the following relative values for the mean spherical intensity with 4, 6, 7, and 10 readings :—



Width of Zones.	Number of Measurements.	Intensity.
30	4	0·868
18	6	0·863
15	7	0·864
10	10	0·8683

To determine the correcting factor for the reflection from the mirrors, the mean horizontal intensity is determined with the frame turned about A through 90° from the position shown in the diagram, and again by direct vision with the mirrors S_3 and S'_3 removed. A photograph of the apparatus as made by Stoehorer and Sons, Leipzig, is shown in the paper. J. B. H.

54. *Efficiency of Acetylene Flame.* **E. L. Nichols.** (Phys. Rev. 11. pp. 215–229, Oct., 1900. Paper read before the American Physical Society, June 27, 1900.)—To determine the total efficiency of a flat flame produced from ordinary gas made by throwing calcium carbide on water, preliminary experiments were made to find the radiant efficiency, the heat of combustion and the ratio of total heat generated to total radiation. Stewart and Hoxie, using an iron wire bolometer, find the value 0·105 for the radiant efficiency. Experiments show that an iodine cell absorbs 51 per cent. of the energy which passes through a water cell, and the value 0·207 being found for the ratio of the light energy transmitted through the water cell to the total energy reaching the bolometer when the cell is interposed, the radiant efficiency is thus found to be 0·51 × 0·207 = 0·105. The heat of combustion as found by Rands with a Favre and Silbermann calorimeter is 10,000 calories. The method of determining the relation between the total heat generated in the flame and the heat dissipated in the form of radiation is described, the experiments being still in progress. Two values of the total efficiency as found by Ball are given, viz., 0·0236 and 0·0199, of which the former is the more reliable. G. E. A.

55. *Zeeman Effect.* **H. M. Reese.** (Astrophys. Journ. 12. pp. 120–135, Sept., 1900.)—The object of the investigation was to study the spectra of various elements in the magnetic field, and to determine the law of variation with the strength of the field. Curves were plotted with field strengths as abscissæ and separations as ordinates. In measuring the sextuplets, they were treated as quadruplets, the measurement of $\Delta\lambda$ being the distance between the two lateral components on one side and that of those on the other. In the case of the three zinc lines, the curve for the triplet is perfectly straight within experimental errors, except that it shows a slight tendency to droop at the highest field attainable as if the separation approached a limiting value. The curve for the quadruplet shows this tendency to a greater degree, and in that for the diffuse triplet it is quite pronounced, beginning at a field strength of 20,200 units. The other metals examined were cadmium, magnesium, iron, nickel, titanium, carbon, calcium, aluminium, silicon, and mercury. The following table gives some figures showing the dependence of the widening upon the field strength :—

Substance.	Line.	$\frac{\Delta\lambda}{H\lambda^2}$
Cadmium........................	4678·37	17×10^{-5}
Cadmium........................	4800·09	$15·5 \times 10^{-5}$
Cadmium........................	5086·06	$10·5 \times 10^{-5}$
Zinc	4680·38	17×10^{-5}
Zinc	4722·26	$15·3 \times 10^{-5}$
Zinc	4810·71	$11·3 \times 10^{-5}$
Magnesium	5167·55	$16·7 \times 10^{-5}$
Magnesium	5172·87	$14·9 \times 10^{-5}$
Magnesium	5183·84	$10·5 \times 10^{-5}$

A few cases of dissymmetry are enumerated [see also Abstract No. 2158 (1900)]. E. E. F.

56. *Arc Spectrum of Iron.* **H. Kayser.** (Ann. d. Physik, 3. 2. pp. 195–203, Oct., 1900.)—Rowland's normal iron lines not being sufficiently numerous to give accurate interpolations, the author supplements them by some 300 additional lines, determined with a maximum error of 0·003 Ångstrom units. The lines are comprised within the limits of 2,300 and 4,500 Ångstrom units, and cover the extent of the usual photographic spectrum. E. E. F.

57. *Arc Spectra of Metals in Hydrogen.* **H. Crew.** (Astrophys. Journ. 12. pp. 167–175, Oct., 1900.)—The author was led to investigate the spectra of various metals by the hope that the altered conditions might have some influence on the grouping of the spectrum lines and that their classing into series might be facilitated. The general effect of hydrogen on the arc-spectrum is a marked diminution of intensity, in many cases to as much as one-hundredth the normal values. In addition to such a general effect, however, the important fact was noted that there was a selective action on certain lines only, some lines being intensified, others weakened or suppressed altogether. Many of these intensified lines are what have been previously considered only *spark* lines. Tables are given showing the lines affected in this manner in the spectra of magnesium, iron, and zinc. From these the author concludes :—

(1) That all lines in the arc-spectrum which are affected by hydrogen, whether enhanced or weakened in intensity, belongs also to the spark spectrum.

(2) The lines which are known to belong to Kayser and Runge's series are unaffected by the change from air to hydrogen. C. P. B.

58. *Photography of Ultra-red Rays.* **G. Meyer.** (Phys. Zeitschr. 2. pp. 6–7, Oct. 6, 1900. Paper read before the 72nd Naturforscherversammlung at Aachen.)—Infra-red photography has not been followed up, Abney's method of preparing plates being complex and not always successful. In Burbank's mode of preparing plates (Phil. Mag., 1878) the use of quinine is not essential, the results being the same without it. These plates may be developed in dilute glycin developer, cooled down by addition of ice. With a diffraction grating, a ray filter must be used, consisting of ruby glass. Glass in the spectrograph scatters red light and fogs the plates by a general diffusion combined with a solarising action of the infra-red rays (Abney) which is more marked the greater their wave-length ; it should therefore be avoided. But with a ruby ray filter absorbing all as far as D, the conjoined action of the diffused red and the infra-red produces positives in which the lines up to 1,200μ can be recognised. In cases of line spectra the disturbing effect of red light is insignificant, and in these cases glass lenses may be used. A. D.

59. *Spectra of Hydrogen and of Aqueous Vapour.* **J. Trowbridge.** (Phil. Mag. 50. pp. 338–347, Sept., 1900.)—An illustrated paper devoted to proving that the "white spectrum" of hydrogen, consisting of many widely distributed lines, is the true one, and that the "four-line spectrum" is due to aqueous vapour, and therefore, in the solar atmosphere and elsewhere indicates the presence of oxygen. Under powerful condenser discharges, H, N, or air all yield this spectrum, due to aqueous vapour liberated from the glass : aluminium electrodes also persistently yield various compounds of N, H, and O. Conclusions as to the temperature of the stars are misleading if based on conditions of pressure and temperature in glass vessels, as electrical dissociation is the most important factor. The white spectrum of H is developed by a steady current which should not exceed a certain strength. "X-ray phenomena, produced by a steady battery-current, strongly suggest an electrical theory of the origin of the sun's corona." S. R.

60. *Infra-red Portion of the Solar Spectrum.* **S. P. Langley.** (Comptes Rendus, 131. pp. 734–736, Nov. 5, 1900.)—The author gives a brief summary of the results obtained during the last six years in the study of the infra-red part of the solar spectrum. He presented to the Academy the proofs of the

last official volume which terminates the series of researches commenced in 1881 on the summit of Mount Whitney in California, at a height of about 4,000 metres. Owing to improvements in methods and apparatus, especially in the bolometer, during the last six years, more than 400 lines have been added to those previously described, and their position has been fixed for the first time. In all about 600 lines are given in the tables of the volume referred to; these lines belong to the infra-red part of the spectrum comprised between $\lambda = 1{\cdot}8\mu$ and $\lambda = 5{\cdot}3\mu$ and their observation has extended over eighteen years.

While the increased sensibility of the apparatus has caused the new lines discovered during the last three or four years to be much more numerous than those formerly observed, at the same time the precision and certainty of the results have increased. Each line has been the object of a separate study: it has been determined by the combination of six to twenty independent observations: all the determinations have been made by means of a delicate micrometric apparatus.

Another point to which the author calls attention relates to the comparative studies of the infra-red telluric spectra which have been made during all seasons during five years from 1895 to 1900. Systematic variations of the spectrum have been observed, which appear in relation with the changes proper to each season. These variations are small but quite distinct. Predictions of changes may be possible and in the future may be valuable to agriculture. The author commends observations of this order to the notice of meteorological observatories in different parts of the globe.

J. Janssen. (Comptes Rendus, 131. pp. 737–738, Nov. 5, 1900.)—Janssen calls the attention of physical astronomers and meteorologists to the interest of Langley's remarks on the modifications which occur in the infra-red part of the spectrum at different seasons of the year. He draws attention especially to the variations of the quantity of atmospheric ozone. This plays such a part in the phenomena which relate to life that its study is of peculiar importance. Spectral observations allow of inquiry into the condition of the high layers of the atmosphere. Such observations are carried out on Mont Blanc and have a great interest on account of the height of the station. To-day the *telluric rays* (whose existence was proved in 1862) permit not only of the recognition of the presence of bodies of the most different kind which can exist in our atmosphere, but are able also to show the most delicate variations in their quantity. J. J. S.

61. *Prism and Grating Spectroscopes.* **N. E. Dorsey.** (Astrophys. Journ. 12. pp. 164–165, Sept., 1900.)—Observations were made with the object of determining whether in the refraction of light it requires time for the medium to reach a steady state; *i.e.*, whether a short train of waves is refracted in the same way as a long train of the same period. A plane grating spectroscope and a prism spectroscope with a long train of prisms were adjusted so that the spectrum of the same source could be examined in each instrument; then the slit was adjusted so that when the source was continuous (*e.g.*, an arc lamp) the spectrum was as nearly as possible the same in both instruments; then the arc was replaced by a very quick spark and the spectra again compared. If the initial disturbance is refracted differently from a continuous one, then in the second case the lines as seen in the prism instrument should be broadened or rendered hazy on one or both sides as compared with the same lines in the grating spectroscope.

A small plane grating and a two-story Grubb spectroscope with ten 60-degree prisms were used. The spark spectrum as given by the Grubb instrument was very faint and the results were unsatisfactory; but not the slightest effect was seen. The total duration of the light from each spark was about 10^{-7} seconds as measured by a rotating mirror. While this is too short to give sufficient light, it is probably much too long to render visible the effect sought even under good conditions. On comparison it was found that for a continuous spectrum of moderate intensity the grating is in the red four, in the yellow five, in the green six, and in the blue eight times as efficient as the Grubb instrument: the efficiency being defined as the ratio of the product of the intensity of the spectrum by its width to the total amount of light striking the first prism or grating. J. J. S.

62. *New Spectrometer Slit.* **C. Fritsch.** (Phys. Zeitschr. 1. pp. 543–544, Sept. 1, 1900.)—The method is here recommended of removing some of the silvering from a mirror to produce a slit for a spectrometer and other similar instruments. An ordinary silver-on-glass mirror is used and fixed on the slide-rest of a lathe; a steel tool, whose point is of the width desired for the slit, is then pressed against the mirror while it is traversed along. The light freely traverses the glass where the silvering is removed, the silver left forming the opaque sides of this optical slit. A slit so made divided the D-line with a single crown-glass prism, and, when used with an Eder's quartz-spectrograph, yielded photographs of ultra-violet spark-spectra as sharp as those published by Eder himself. E. H. B.

63. *Becquerel Rays.* **M. Maier.** (Phys. Zeitschr. 2. pp. 33–34, Oct. 20, 1900.)—Experiments made with a Giesel preparation of radio-active barium chloride show that it possesses a great penetrating power. With an exposure of four minutes the rays passed through an iron plate 4 mm. thick and a layer of mercury almost 20 mm. thick. The rays from the barium, which is phosphorescent, are very diffusely reflected from various bodies, and no evidence could be found that they undergo regular reflection, refraction, or diffraction. G. E. A.

64. *Phosphorescence of Inorganic Compounds.* **E. Goldstein.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 38. pp. 818–828, July 26, 1900.)—The author employs the expedient of making the phosphorescent body move rapidly through a beam of kathode rays, so that any instantaneous phosphorescence is shown by the substance while still within the beam, and any subsequent luminescence is shown by the luminous tail visible on the substance after it has passed through. The substances are in the state of powder, so that the luminous effect is that of a cascade headed by the instantaneous luminescence, and of length proportional to the remanent luminosity. The author is driven to the conclusion that in the inorganic substances examined only the instantaneous luminescence is due to the substance itself, while the remanent luminosity is due to impurities. The apparently irregular character of the colourations is after all subject to definite rules, once the substances are carefully purified. One of these rules is that those metals which possess colourless oxides show a blue or violet instantaneous luminescence. Remanent luminescence may be produced by adding other metals in very small percentages, say 0·0001 per cent. Such small impurities cannot be detected by any chemical reaction, and the examination of the substances by kathode-ray luminescence therefore gives us a new and very delicate test for impurities. The positive light also produces luminescence under certain conditions. E. E. F.

REFERENCES.

65. *Field of Reflecting Telescope.* **S. C. Reese.** (Astrophys. Journ. 12. pp. 219–227, Oct., 1900.)—A mathematical proof is here given of the fact that in a reflecting telescope there does not exist any field, plane or curved, on which the image of a star off the axis is either a sharp diffraction disc (either round or linear) or a single blurred circle. Very near the axis the distortion of the image is negligible. J. B. H.

66. *Zonal Aberration and Wave Surfaces.* **K. Strehl.** (Zeitschr. Instrumentenk. 20. pp. 266–269, Sept., 1900.)—Mathematical discussion and application to some particular microscopic and photographic lens-systems. A. D.

67. *Phosphorescence Produced by Radiation from Radium.* **H. Becquerel.** (Soc. Franç. Phys., Séances, 4. pp. 179–185, 1899.)—Paper similar to that referred to in Abstract No. 632 (1900).

68. *Becquerel Rays.* **O. M. Stewart.** (Phys. Rev. 11. pp. 155–175, Sept., 1900.)—A thorough, classified *résumé* of the work done on this subject, bringing up to date a former article [Abstract No. 1135 (1898).] G. E. A.

69. *Interferential Measures of Wave-Length.* **A. Pérot** and **C. Fabry.** (Comptes Rendus, 131. pp. 700–702, Oct. 29, 1900.)—The paper describes the method of directly measuring the absolute wave-length of any solar Fraunhöfer line by means of the interferential spectrometer. C. P. B.

70. *Spectra of Gaseous Mixtures.* **E. Goldstein.** (Deutsch. Phys. Gesell., Verh. 2. 10. pp. 110–112, 1900.)—The paper consists of comments on some recent work by Lewis [Abstracts Nos. 468 and 1798 (1900)] on the effects of certain gases when present as impurities in others on the spectra of the latter. C. P. B.

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71. *Law of Radiation.* **O. Lummer** and **E. Jahnke.** (Ann. d. Physik, 3. 2. pp. 283–297, Oct., 1900.)—Thiesen's equation for the energy of radiation as dependent upon temperature and wave-length states that for any given wave-length the energy increases indefinitely with the temperature, or in other words, that there is no limit to the amplitude of the vibration which gives rise to that particular ray. The same view is taken by Michelson, whereas W. Wien considers that with rising temperature the energy of every wave-length approaches a finite limit, such as in the case of sound would be prescribed by the breaking strength of the vibrating material. The authors have endeavoured to throw some light on this matter by obtaining a general formula from which the two contending formulæ could be deduced by altering the constants. The equation so obtained is—

$$E = cT^5(\lambda T)^{-\mu}e^{-\frac{c}{\lambda T}}.$$

Wien's equation is obtained from it by putting $\mu = 5$, Thiesen's by putting $\mu = 4{\cdot}5$, and Rayleigh's by putting $\mu = 4$. It is only in the first case that E may have a finite limit. Apart from the intrinsic improbability of just that case occurring, $\mu < 5$ is most in accordance with Maxwell's law of distribution; and if Lummer and Pringsheim's figures really represent the intensity of black radiation, the value $\mu = 4{\cdot}5$ is the only admissible one. E. E. F.

72. *Specific Heats of Alloys.* **E. van Aubel.** (Phys. Zeitschr. 1. pp. 452–453, July 21, 1900, and Journ. de Physique, 9. pp. 493–497, Sept., 1900.)—The theoretical importance of the possible reduction of specific heat with increasing temperature, known to occur in the case of mercury, and alleged to take place also in Arcet's and Lipowitz's alloys, studied by Spring, has led the author to inquire whether the values found by Spring by means of the cooling method are correct, and whether they are in agreement with Regnault's law of mixture. D. Mazzotto found for the specific heat of Lipowitz's bismuth-tin-lead-cadmium alloy a specific heat of 0·0354 between 5° and 50°, whereas Spring found it to be 0·0634 at 28°, 0·0554 at 50°, and 0·0625 at 90·5°. The theoretical value after Regnault is 0·03655, which agrees well with Mazzotto's value, but is considerably below the smallest of Spring's values. Similarly, the theoretical value for the specific heat of Arcet's bismuth-tin-lead alloy is considerably below Spring's experimental value. The author concludes that Spring's values are vitiated by the unsuitability of the cooling method for any but liquid substances, and that the alleged fall of specific heat with rising temperature does not occur. E. E. F.

73. *Limits of the Solid State, V.* **G. Tammann.** (Ann. d. Physik, 3. 2. pp. 161–194, Oct., 1900.)—If in one point of the equilibrium curve of two phases, of which one at least is crystallised, the volumes are equal, then the energies are different, and if the energies of both phases are equal, then the volumes differ. The second portion of this theorem having already been proved by the author's work on ice, it remained to prove the first portion. And this is now done by the author's experiments on benzol, naphthalene, phosphorus, and dimethylethyl carbinol. Compared with the volume changes on the curve of fusion, the diminution of the heat of fusion is very small. This makes it very improbable that Δv and r (the heat of fusion) pass together through the value zero at any point of the fusion curve. In the case of dimethylethyl carbinol the volume change was followed up to within 10° of the point at which, by extrapolation, it should pass through zero. In a range of temperature of 40° the heat of fusion shows no sensible change. Should the heat of fusion and the volume change become zero together, that would involve a turn of the curves which is quite inconsistent with the known portions. The conditions for a critical point do not seem to exist. [See also Abstract No. 1659 (1900).] E. E. F.

74. *Constants of Diisopropyl and Diisobutyl.* **S. Young** and **E. C. Fortey.** (Chem. Soc., Journ. 77. and 78. pp. 1126–1144, Sept., 1900.)—In order to investigate further [see Abstract No. 79 (1900)] deviations from the generalisations of Van der Waals in the case of isomeric substances, the authors compared di*iso*propyl and di*iso*butyl with the corresponding normal paraffins. Specimens of these substances were prepared by the action of sodium on *iso*propyl iodide and *iso*butyl bromide respectively, in ethereal solution, and then carefully purified, in the former case the preparation being difficult and the yield very poor. It is remarkable that the di*iso*propyl was denser than normal hexane, whilst the known *iso*paraffins are invariably less dense than the corresponding normal hydrocarbons, and the di*iso*butyl was considerably less dense than normal octane. Another specimen of di*iso*propyl was therefore prepared by electrolysis of potassium *iso*butyrate, the gases evolved being absorbed in order to avoid loss. Under the best conditions 100 gms. of *iso*butyric acid gave only 1·5 gms. of moderately pure di*iso*propyl, the theoretical yield being 49 gms. The high specific gravity of di*iso*propyl was confirmed.

The boiling-points, vapour pressures, gramme and molecular volumes at various temperatures, critical volumes (by the method of Cailletet and Mathias corrected for slight curvature of the "diameter"), gramme and molecular volumes of the saturated vapours were determined from specimens prepared by the former of the above methods. Among other results the following were obtained :—

Di*iso*propyl	Boiling-point (760 mm.)	58·08°
	Specific gravity	0·67948
	Critical temperature	227·4°
	Critical pressure (mm.)	23345
	Critical volume (molecular in c.c.)	356·0
Di*iso*butyl	Boiling-point (760 mm.)	109·2°
	Specific gravity	0·71021
	Critical temperature	276·8°
	Critical pressure (mm.)	18650
	Critical volume (molecular in c.c.)	480·8

The absolute temperatures and molecular volumes of the two hydrocarbons, both as liquid and as saturated vapour, were read from the curves at the usual series of "reduced pressures." With few exceptions the ratios of (*a*) the absolute temperatures at any series of corresponding pressures to the absolute critical temperatures, (*c*) the volumes of saturated vapour to the critical volumes, (*d*) the actual to the theoretical densities at the critical points, are higher for the normal paraffins than for their isomerides; but the ratios (*b*) of the volumes of liquid to the critical volumes are lower for the normal paraffins than for the corresponding *iso*- or di*iso*-compounds. Comparing these results with those obtained for methyl butyrate and methyl *iso*butyrate, the authors regard the statements made in reference to *a*, *b*, *c*, as representing general laws, but the differences in the case of *d* as too small to allow of any definite conclusion being drawn. The double *iso*-group has generally about twice the effect of the single group, but the great irregularities in the case of di*iso*propyl show that something must be taken into account beyond the mere presence of the di*iso*-group. W. E. T.

75. *Constants of Normal Octane.* **S. Young.** (Chem. Soc., Journ. 77. and 78. pp. 1145–1151, Sept., 1900.)—The author made determinations for normal octane similar to those made for other paraffins [see preceding Abstract]. A specimen prepared from octyl iodide was very carefully purified. The vapour pressures were measured from 2 to 140 mm. by Ramsay and Young's method, from 160 mm. to atmospheric pressure with a modified distillation bulb provided with a reflux condenser, and for high temperatures with the pressure apparatus employed by the author in his previous researches. The differences between the calculated and observed pressures, as is the case with stannic chloride and acetic acid, which also have their critical temperatures higher than 280°, near the critical point were greater than with most substances examined. The author concludes that the boiling-point of bromonaphthalene had been estimated too low by Ramsay and himself, probably owing to their employing Regnault's values of the vapour pressures of mercury.

Among other results the following were obtained :—

Specific Gravity	0·71848
Boiling-point (760 mm.)	125·8°
Critical temperature	296·2°
Critical pressure	18730 mm.
Critical volume (molecular)	488·9 c.c.

The results obtained confirm previous conclusions that the ratios *a*, *d* (see preceding Abstract) increase, while the ratios *b* diminish with rise of molecular weight. W. E. T.

76. *Gas Thermometry.* **P. Chappuis.** (Phil. Mag. 50. pp. 433–442, Oct., 1900. Paper read before the Physical Society of London.)—The author tests an assumption made in a previous investigation [see Abstract No. 637 (1900)], viz., that the thermometric scale of a constant-volume nitrogen-thermometer with an initial pressure of less than 800 mm. of mercury agrees with the normal scale at high temperatures. He finds that the coefficient of dilatation of nitrogen diminishes gradually up to about 80°, and then increases very slightly; probably it approaches a definite limiting value for each initial pressure, nitrogen at 100° behaving like hydrogen at ordinary temperatures, with a compressibility less than is required by Boyle's law. From 100° to 500° the pressures indicated by a constant-volume gas thermometer are a little too low, but the errors are small and of less account than other sources of uncertainty, even when the initial pressure is 1 metre of mercury. With lower initial pressures the divergences are probably diminished, and, with the thermometer previously employed, less than 0·04° for temperatures at the boiling-point of sulphur. The author attributes the difference between the value (445·2°) found by Harker and himself for this point, and that determined

by Callendar and Griffiths (444·53°), firstly to the fact that the scale of the constant-pressure nitrogen-thermometer differs more from the normal scale than does that of the constant-volume nitrogen-thermometer, secondly to the use by Callendar and Griffiths of too high a coefficient of expansion of air at constant pressure, and possibly to error in the coefficient of dilatation of the material of the gas-reservoir. He compares his own observations on the dilatation of porcelain, by Fizeau's method, with those of Bedford, who directly measured the distance between two marks on the porcelain tube by means of a comparator provided with two microscopes. In the latter case observations of the dilatation were made over the range of temperature for which the thermometer was to be employed, while in the former case extrapolation was necessary to an interval about four times as great as that in which observations were made. However, it is pointed out, that, as the marks on the tube were 8 mm. distant from the neutral plane, the mode of support of the tube exercised a considerable influence on the results obtained, and also that there might be sensible variations, as yet undetermined, in the elastic constants of porcelain at high temperatures. The hole in Bedford's tube was eccentric, variations of 2 to 4 mm. occurring in the thickness of its wall, and, as the porcelain and the glaze of the tube had slightly different coefficients of expansion, deformations probably occurred on heating. The author's observations on a specimen of the same tube point to a larger coefficient of expansion than that determined by Bedford, and indicate that the cause of this is an inequality in the dilatation of the two opposite sides of the tube, which necessarily involves a change in its form.

The paper concludes with a table of corrections applicable to the platinum thermometer scale, in which the sulphur boiling-point is assumed to be 444·53°, to transform it to the new scale, for which the sulphur boiling-point is 445·2°. W. E. T.

77. *Platinum Thermometry.* **C. Chree.** (Roy. Soc., Proc. 67. pp. 3–58, Oct. 8, 1900.)—An account is given of experiments conducted at Kew Observatory during the years 1895–1899 on the behaviour of seven platinum thermometers, of which six were certainly, and the seventh probably, constructed of the same sample of platinum wire. The original installation was described in *Nature*, Nov. 14, 1895. In the resistance-box at first used, which had a plug system of the ordinary Post Office pattern, it was found after a time that pulling out a plug influenced the tightness of its neighbours; it was therefore improved by the introduction of a new system of plug-holders (fusible metal inside Doulton ware) in which the plug-holders were separately supported. The bridge wire was of platinum silver, having the same temperature coefficient as the coils; a difference of reading of 1 cm. on it answered nearly to one box unit, or to a difference of temperature of 1° with all the thermometers but one; it would have been desirable for 1 cm. on the bridge wire to have answered to not more than 0·1° C.

Excluding observational errors and defects, such as moisture in the tube surrounding the platinum wire, 17 causes of change in the readings or of error were examined. Changes in the relative resistances of the leads were found to occur, which led to errors at least of the order 0·01° or 0·02° unless special means of eliminating them were adopted. To guard against errors arising from *slow regular* changes in the relative resistances either of the leads or of the proportional arms frequent zero-point observations were necessary. Also frequent calibrations of the box coils, however laborious, could hardly be avoided in physical work of the highest accuracy. Uncertainty of the order

0·04° was found to arise owing to shift of the bridge centre. During a day's observations this was found to drift. Error owing to thermoelectric currents was diminished by putting in a padded box the Griffiths key employed, but it was still advisable to take readings with the current in opposite directions. Even with only one dry cell in use, considerable uncertainty was introduced, if 20 ohms were inserted in the battery circuit instead of 100 ohms; unless the heating effect of the current can be exactly ascertained and allowed for, the sensitiveness of the galvanometer used should be largely increased.

When a comparison is required between observations made on different days, and therefore the absolute values of the platinum resistances are required, error in the temperature coefficient of the coils is of importance. The author recommends that the entire room containing the apparatus should be kept at the standard temperature of the coils, and that one standard temperature should be adopted for summer, another for winter. It is also desirable that the bridge wire should be better protected than in the Kew box, and its temperature measured directly. The immersion of the thermometer should be for at least 10 cm. in addition to the length of the bulb; he suggests that owing to insufficient immersion the value of the melting-point of silver, as determined by Hugo and himself, was too low.

Platinum thermometers were found to be extremely *slow*, compared with mercury thermometers. The author thinks that appreciable error arises from the reduction of sulphur-point observations to standard barometric pressure, and arrives at the formula—

$$t = t_s + 0{\cdot}090\,(p - 760) + 0{\cdot}0002\,(p - 760)^2,$$

instead of Callendar's linear formula; further experiments on the question are desirable.

The resistances of the thermometers at the fixed points appear to have continued constant, except in the case of those exposed to high temperatures, such as the melting-point of silver. In one case two exposures to the sulphur-point and two to the temperature of molten silver produced a fall of approximately 0·7° in the zero-point. Differences occur between the temperatures recorded by the different thermometers. The phenomena presented are in the main the same as if the spirals consisted of given equal lengths of identical platinum, and in addition of variable lengths of a material, whose temperature coefficient is higher than platinum, and of which the resistances at the ice-, steam-, and sulphur-points are approximately as 1 : 1·6 : 3·6. The real nature of the underlying physical fact calls for further examination. Experiments are also desirable on the behaviour of *new* platinum thermometers, and on the effect of long or frequent exposures to very high and very low temperatures. W. E. T.

78. *Effect of Impurities in Platinum Thermometers.* **H. M. Tory.** (Phil. Mag. 50. pp. 421–432, Oct., 1900. Paper read before the Physical Society of London.)—The author gives an account of an investigation, the main purpose of which was to estimate the probable degree of accuracy attained in the determination of high temperatures by resistance thermometers constructed of commercial platinum wire. Five wires were compared over the range 400° C. to 1,000° C. Although they differed widely in purity the extreme variations of the temperatures observed, when calculated on the platinum scale by the formula—

$$pt = 100\,(\mathrm{R} - \mathrm{R}^\circ)/(\mathrm{R}' - \mathrm{R}_\circ),$$

R, R′, R° being the observed resistances at the temperatures pt, 100° C.

and 0° C. respectively, were not more than 9° C. at 1,000° C. When the temperatures were reduced by the difference formula—

$$t - pt = dt(t - 100) / 10{,}000,$$

in which the difference coefficient d was calculated by assuming the boiling-point of sulphur, the variations at 1,000° C. were still from 5° C. to 10° C. If, however, the freezing-point of silver was employed to determine d, close agreement was obtained at high temperatures.

Curves are given, which show graphically that a linear relation, involving only two unknown quantities, connects the temperatures determined by each of the tested wires and the standard. The most consistent results for all the wires were obtained by reducing the observed values of pt by the linear relation and correcting the reduced values by the difference formula of the standard wire. This method would be inapplicable below 400° C., but it might be suitable for purposes of extrapolation. Heycock and Neville's method of reduction, by which the observed pt for any pyrometer is reduced to the normal scale by taking from a difference curve, drawn for the standard wire in terms of pt as abscissa, the corresponding $t - pt$ and increasing it in the ratio (d/d^0) of the appropriate difference coefficient d to the standard d^0, was found to give the best results for two of the wires, but not to apply well to the more impure specimens. The conclusion is drawn that from 0° C. up to the melting-point of gold, at least, a practical thermometric scale can be established at no point differing from the gas-thermometer scale by more than 2° C. or 3° C., and that observers working with platinum pyrometers can compare their results. The standard sample may be defined as a wire with a definite sulphur boiling-point and a definite silver melting-point. The author has not yet studied differences below 400° C. or above 1,000° C., but the linear difference curve appears to bend below 400° C. Such reduction as the above, however, is hardly necessary below 400° C., as for any good platinum wire the temperature there can be reduced directly by the difference formula, d being calculated from the sulphur boiling-point.

If the impurities in the platinum wire consisted of the baser metals no consistent results were obtained until the volatile constituents had been burnt out. No change of zero of importance was observed except one of the order of 1° C. after the first exposure to 1,000° C., which was probably due to impurities in the mica on which the wire was wound, or to the wire having been in a state of tension when wound. Drawing of the wire was found not to affect the indications of the standard wire, if both wires were properly annealed.

Callendar's method of comparison was adopted. The galvanometer used was specially designed by Callendar for resistance pyrometer work, with an astatic needle system in which the control is due to the passage of a current through a pair of coils at right angles to the galvanometer coils; the control current is proportional to that used in measuring the resistance, and therefore the deflexion due to a given difference of resistance is independent of the strength of the current. The deflexions could be read to $\frac{1}{100}$ of a degree. The pyrometers, enclosed in a porcelain tube, were heated in a bath of molten tin, the gas supply being regulated by a constant-pressure gas-regulator. To prevent oxidation the tin was covered with a layer of finely-ground arc-light carbon. Much difficulty was experienced owing to the action of the tin on the porcelain tubes.
W. E. T.

79. *Gas Thermometer for High Temperatures.* II. **L. Holborn** and **A. L. Day.** (Amer. Journ. Sci. 10. pp. 171–206, Sept., 1900.)—For due correc-

tion of the readings of the thermometers investigated [see Abstract No. 86 (1900)] the expansibilities of the envelopes must be known. The linear expansibilities of rods of platin-iridium (80Pt, 20Ir), platinum, porcelain, and Jena glass 59^{III} were therefore measured: for PtIr

$$a = 8{\cdot}198 \times 10^{-6},\quad b = 1{\cdot}418 \times 10^{-9},$$

in the formula

$$l/l_0 = 1 + at + bt^2,$$

and for Pt

$$a = 8{\cdot}889 \times 10^{-6},\quad b = 1{\cdot}274 \times 10^{-9},$$

from 0° to 1,000° C.; for porcelain

$$a = 2{\cdot}954 \times 10^{-6},\quad b = 1{\cdot}125 \times 10^{-9},$$

from 250° to 625° and at 1,000°, these coefficients giving too large values outside the named ranges; for the glass the results obtained varied with the way in which the glass was treated, but on the whole, $a = 1{\cdot}8 \times 10^{-5}$, and $b = 0$, up to 500° C.

The possible yielding of the walls of the envelope, temporary or permanent, when glowing and under the comparatively high pressure of the heated gas was examined, but was not found to occur with a PtIr bulb. Thorough comparisons with the gas thermometer were also made of the thermo-elements employed, and the following melting-points were determined:—

Cadmium	321·7	(320·7)	Silver (in air)...	955·0	(955·0)
Lead	326·9	(327·7)	„ (pure) ...	961·5	(960·7)
Zinc	419·0	(419·0)	Gold...............	1064·0	(1061·7)
Antimony	630·6	(629·5)	Copper (in air)	1064·9	
Aluminium ...	657·0	(654·5)	„ (pure)	1084·1	(1080·5)

The temperatures given in brackets are the melting-points found by Callendar and by Heycock and Neville with platinum resistance thermometers.

R. E. B.

80. *Thermodynamics.* **K. v. Wesendonck.** (Ann. d. Physik, 2. 4. pp. 746–756, Aug., 1900.)—The author discusses the question as to whether in Clausius's equation—

$$\int \frac{dQ}{T} \leqq 0,$$

the absolute temperature T is that of reservoirs of heat, or of parts of the bodies undergoing the cyclic process. The former alternative is implied by Kelvin's treatment. Poincaré puts the equation into the form—

$$\iint \frac{dQ}{T} \leqq 0,$$

where the integration covers all the elements of the working system, and T is the temperature of an element. The author doubts, however, whether this equation would hold good for great differences of temperature, though he believes that the temperature of the reservoirs of heat should not enter into the equation. Concerning the second law of thermodynamics, he is of opinion that it would be better not to found it entirely upon the doctrine of entropy, since it is not proved that in any system one state may be reached from another state along an irreversible path. Planck's treatment may fail to be conclusive when other work besides mechanical work is done by the cycle. If it were conclusive, it would lead to doubts concerning the general application of the principle of entropy.

E. E. F.

81. *Heat-Engine Diagrams.* **R. H. Thurston.** (Science, 12. p. 402, Sept. 14, 1900.)—In addition to two isothermals and two isentropics for gases on a *pv*-diagram it is convenient to draw two isopiestics and two isometrics to intersect the other lines outside the Carnot cycle which they form : for 17 different types of gas-engine, cycles are thus indicated on a single diagram. There may also be drawn on it two isothermals and two isentropics for a vapour, so as to illustrate a Rankine cycle as well. R. E. B.

82. *Permanent Changes and Thermodynamics.* **P. Duhem.** (Zeitschr. Phys. Chem. 34. pp. 312–377, July 31 ; and 683–700, Sept. 18, 1900.)—These papers are two more of a series of memoirs by Duhem, and are in great part based on his conclusions arrived at in the earlier ones, notably the last one [Abstract No. 1821 (1900)]. In that memoir the subject was treated principally from the theoretic point of view. In the present one he employs his formulæ (chap. ii. of the last memoir and elsewhere) to elucidate and reduce to system certain chemical phenomena and also certain phenomena observed in practical metallurgy. The first chapter treats of hardness (Härtung) as undergoing secular changes (a word introduced by C. Barus to express a process that may take years to become sensible), with two sub-sections on chemical changes, especially that of red phosphorus, and on the degree of hardness (Härtung) of a metal. The writer here considers a solid body of which each elementary part consists of a homogeneous mixture of two substances, α and β, either of which is capable of transformation into the other. The quantities of α and β per unit of volume are $1-x$ and x respectively. The state of the body is completely defined by the chemical variable x, the specific volume v, and the temperature τ. An external pressure π is assumed. Finally it is assumed, with reference to the last memoir (chap. ii.) that x is affected by hysteresis, while v is free from it. Corresponding with the convention adopted in that chapter, α and β are to be so chosen as to satisfy the inequation—

$$\lambda(x, \pi, \tau) > 0.$$

The second chapter treats of alloys of iron and nickel. Following C. H. Guillaume [Abstract No. 1115 (1898)] the writer divides these into irreversible alloys, which contain less than 25 per cent. of nickel, and reversible if they contain more than that percentage. The third chapter deals with the overheating (Verbrennen) of metals, and the fourth with the forge. The whole is copiously illustrated by diagrams, which, however, could not be usefully reproduced in this Abstract.

The second of these two papers treats of certain methods of approximation by which a system depending on two variables, subject to hysteresis, may be investigated. The two variables, a, x, with the temperature τ for third variable correspond to a curve in space. If two such curves do not intersect, nevertheless their projections on one of the co-ordinate planes may intersect. Such intersections Duhem calls apparent intersections, and illustrates them by diagrams taken from Ewing's treatise on magnetic hysteresis. In chapter ii. of this paper Duhem treats of a system in which the hardness undergoes only secular changes defined in a former paper of the series. If this be denoted by x, one of the two variables, changes depending on x will be very small. The system will behave approximately as a system with only one normal variable ; systems of this kind have been discussed in the fifth paper of the series (chap. i.). In this principle consists the method of approximation explained in the present paper. If A, X, express the external conditions corresponding to the variables a, x, then a "natural state" is defined by reducing to zero two functions—

$$f_a(a, x, T, A, X) = 0$$

$$f_x(a, x, T, A, X) = 0$$

The equations obtained by using instead of the variable x a certain constant value C, from which x differs but little as above explained, namely—

$$G_a(a, T, X, A, C) = 0,$$

and—

$$x = E(a, T, X, A, C),$$

define a "fictive natural state."

It is shown that any cycle of variations in the external conditions causes the system to undergo permanent changes of the x and a components, which may be calculated approximately by means of two supposed "fictive" systems, in one of which a and in the other x is unaffected by hysteresis. S. H. B.

83. *Relationships between Thermodynamic Fundamental Functions.* **J. E. Trevor.** (Journ. Phys. Chem. 4. pp. 570–584, Oct., 1900.)—The fundamental functions are the same as those discussed by Trevor in his former papers [Abstracts Nos. 71 and 635 (1900)], namely, E, F, G, H, which themselves depend on the four usual variables, p, v, θ, η, in the form following :—

E (the energy) satisfies the equation—

$$dE = -p\,dv + \theta\,d\eta,$$

F (the free energy) $= E + \theta\eta$,
G (the heat function) $= E + pv$,
H (the entropy function) $= E + pv - \theta\eta$.

The author now considers the two known relations :—

$$\left.\begin{aligned} \frac{d}{dp}\,\frac{(H_2 - H_1)_{p\theta}}{p} &= -\frac{W_{12}}{p^2} \\ \frac{d}{d\theta}\,\frac{(H_2 - H_1)_{p\theta}}{\theta} &= -\frac{Q_{12}}{\theta^2} \end{aligned}\right\} \qquad (1)$$

in which p and θ denote the equilibrium values of the pressure and thermodynamic temperature, W_{12} and Q_{12} the work and heat respectively absorbed by the system in passing from state 1 to state 2. The subscripts p, θ indicate that the change is effected with p and θ constant, the mass remaining unchanged during the operation.

The object of the present paper is to find other relations of the form (1). To effect this object each of the fundamental functions, E, F, G, H, has to be expressed in terms of each of the others. As an example of the results the author obtains—

$$-v^2\,\frac{d}{dv}\,\frac{(E_2 - E_1)_v}{v} = (G_2 - G_1)v,$$

where the subscript v indicates that v is to be constant during the change from state 1 to state 2.

Then follows a discussion of individual phases. The integration of

$dE = -p\,dv + \theta\,d\eta$ gives $E = -pv + \theta\eta + \Sigma\mu m$, the summation including all the masses of the n independent variables composing a phase. The type of the resulting equations is—

$$G = -v^2 \frac{d}{dv} \frac{E}{v}$$

$$F = -\eta^2 \frac{d}{d\eta} \frac{E}{\eta}$$

$$e = -\Sigma m^2 \frac{d}{dm} \frac{E}{m} - (n-1)E$$

S. H. B.

REFERENCES.

84. *Low Temperatures.* **B. Dessau.** (Phys. Zeitschr. 2. pp. 20–22, Oct. 13; 37–44, Oct. 20; and 60–62, Oct. 27, 1900.)—The author gives a summary of recent work in connection with low temperatures. He deals with the methods of producing them; with the influence of extreme cold upon the physical and chemical properties of bodies; Behn, Trowbridge, and Tilden's work on specific heats; methods of measuring low temperatures; resistance, thermoelectric force, and dielectric capacity at low temperatures; and the solubility of bodies in condensed gases. E. E. F.

85. *Kinetic Theory of Gases.* **S. H. Burbury.** (Ann. d. Physik, 3. 2. pp. 355–365, Oct., 1900.)—The author deals with two objections raised by G. Zemplén against his fundamental principles of the kinetic theory of gases [see Abstract No. 1817 (1900).] He acknowledges that these principles require further explanation.

E. E. F.

86. *Convection Currents in a Liquid Layer.* **H. Bénard.** (Journ. de Physique, 9. pp. 513–524, Oct., 1900.)—Paper similar to that referred to in Abstract No. 1815 (1900). A. D.

87. *Boiling-points of Mixtures of Chloral and Water.* **J. C. Christensen.** (Journ. Phys. Chem. 4. pp. 585–597, Oct., 1900.)—A long series of measurements of the boiling-points of mixtures of chloral and water is given, together with curves plotted therefrom. T. H. P.

SOUND.

88. *Mechanical Effect of Sound-Waves.* **B. Davis.** (Amer. Journ. Sci. 10. pp. 231–236, Sept., 1900.)—If a small cylinder, which is closed at one end, is placed in a stationary sound-wave, it will not only arrange itself perpendicularly to the motion of the wave, but will actually move across the wave in a direction perpendicular to the stream-lines. The closed end of the cylinder is driven towards the wall of the pipe containing the stationary sound-wave. The author produces a continuous rotation of a kind of anemometer wheel in which the cups are replaced by gelatine capsules with flat bottoms, the whole being mounted on a needle-point by means of a glass pivot. The rate of revolution at any point of the organ-pipe is nearly proportional to the velocity of the vibrating air particles at that point. According to Bernouilli, a gas in motion is virtually less dense than a gas at rest. The air in each capsule cylinder is at rest, while that on the outside of it is in motion. The kinetic energy evolved is due to the difference of density on the two sides of the closed end of the cylinder. E. E. F.

89. *Longitudinal Vibrations of Rods.* **G. Jäger.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 81–91, Jan.–March, 1900.)—The lowest longitudinal vibration of a rod free at both ends is an octave higher than the lowest longitudinal vibration of the same rod when one end is absolutely fixed. Such a "fixed" end may be obtained by pressing the rod firmly against a block of lead, or, better, by pressing it into a conical depression in the block. A comparatively small block suffices to obtain the fundamental note and a variety of overtones. Thus for a rod 1 m. long and 6 mm. thick a cylindrical lead weight of 3 cm. radius and 1 cm. thickness suffices. If a table is substituted for the lead block a yet lower note is obtained, due to the vibration of the rod as a whole in the direction of its length. The full number of tones of a rod fixed at both ends may be produced by providing both ends with lead blocks. The notes yielded are very pure. The ease of production is not impaired by shortening the rods. The shortening may be carried so far as to surpass the limit of hearing. With rods less than 4 cm. in length pitches of 50,000 may be attained, or more if real rods are used, which have a high elasticity.

E. E. F.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

90. *Electron Theory.* **W. McF. Orr.** (Phil. Mag. 50. pp. 269–278, Sept., 1900.)—Various points in the theory of electrons as developed by Larmor are criticised. The illustration of the origin of statical mechanical attraction is considered inadequate, inasmuch as it does not show any machinery by which the mobility of the electrons is provided. Some analysis, slightly modified from that of Larmor's, is given showing the conditions of equilibrium of an element of ether. The whole paper is the outcome of a discussion with Larmor, whose rejoinder to this paper is appended. G. E. A.

91. *Dust Figures for Electrostatic Fields.* **D. Robertson.** (Elect. Rev. 47. pp. 370–372, Sept. 7, 1900.)—A wooden frame is held by a clip stand, and in this frame a plate of glass rests loosely. Pressing against the under side of the glass plate, electrodes of tin-foil of any desired shape and size are used. The electrodes are connected by bare wires to the terminals of an electrical machine. The machine is worked to give the electrostatic field, and at the same time the plate is sprinkled with dust and the holder of the clip stand tapped. When the best effect is obtained the tapping should be stopped, and then the bare leads of the machine short-circuited by a wire held ready for the purpose. For the dust, that obtained from mahogany by a tenon saw is suitable. E. H. B.

DISCHARGE AND OSCILLATIONS.

92. *Unipolar Discharge.* **J. Stark.** (Phys. Zeitschr. 2. pp. 17–18, Oct. 13, 1900.)—When the charge of a body is increased beyond a certain point, a disruptive discharge takes place through the surrounding medium. On raising the temperature of the body to incandescence, the discharge potential is lowered, and the lowering is greater for negative than for positive charges. Hence at a certain difference of potential, either positive or negative, a negative charge alone will be discharged. This is the unipolar discharge produced by heating, and the author offers the following explanation for it. At the surface of the glowing body, positive and negative ions are liberated, partly owing to the high temperature, and partly owing to the ultra-violet light radiated from the body. Under the force exerted by the charged body, these ions are driven into the gas, and produce or increase the conductivity of the latter. If the body is negatively charged the negative ions will be sent out with the greater force, and since their speed is greater in every case than the speed of the positive ions, they will produce a greater amount of gaseous ionisation than the positive ions would in a similar case. That ionisation, and not mere field strength, is the determining factor is shown by the fact that if a carbon filament charged to — 100 volts is confronted with an electrode at — 5,000 volts, no charge passes, since the negative ions cannot leave the glowing filament. But a discharge passes at once on earthing the electrode. E. E. F.

93. *Effect of Heat on a Vacuum Discharge.* **J. Stark.** (Ann. d. Physik, 3. 2. pp. 221–242, Oct., 1900.)—As regards change of potential gradient with current strength, the dark spaces are equal among each other, and so are the bright spaces. In the former it increases with the current, in the latter it decreases. Under the influence of heat, the luminous layers show a decrease of potential gradient and an increase of current intensity. The changes described occur first slowly with increasing temperature, then rapidly, and then again slowly. The dark spaces show an opposite behaviour. At a red heat the bright layers become dark and acquire the properties of the latter. E. E. F.

94. *Helical Discharge.* **M. Toepler.** (Phys. Zeitschr. 1. pp. 497–498, Aug. 11, 1900.)—The author describes the conditions under which Ruhmer's helical discharge [see Abstract No. 2204 (1900)] is observed in detail. In the open air the discharge resembles the positive brush with helical stalk described by the author some time ago. In a vacuum the phenomenon is not observed with a continuous current, but only after the discharge has been made disruptive by inserting one or two spark-gaps. The irregular luminous lines shown with feeble currents coalesce into a single band when the current-strength is increased, and the band runs in a helical path along the wall of the tube. As the current-strength increases still further the band detaches itself from the wall of the tube, its pitch becomes higher and eventually it contracts into a nearly straight band joining the two electrodes. Like the helical brush discharge in the open air, the band is carmine red at the anode, and blue along the rest of its length. Pitch and direction of winding often change abruptly and without assignable cause. Sometimes it suffices to trace a screw line with the hand in the opposite sense, to reverse the screw. The helical band turns about its axis, as observed by Ruhmer, apparently descending from the anode to the kathode. The velocity of rotation is much affected by electrostatic influences. E. E. F.

95. *Thermal Extinction of Electric Glow.* **J. Stark.** (Ann. d. Physik, 3. 2. pp. 243–246, Oct., 1900.)—If the influence of heat upon the electric glow in a gas is to be determined it is not advisable to heat the whole tube, as in that case the conditions of discharge are totally changed. The author therefore employs a looped carbon filament, with its plane normal to the axis of the tube, carefully insulated, and rendered incandescent by an independent current. To avoid justifying Lehmann's supposition that the dark space observed round the glowing body is a dark kathode space due to an independent discharge, the author works with a high-potential continuous current rather than an induction coil. All the results point to the theory that a simple increase of temperature stops the luminosity of a gas under an electric discharge. Hittorf's idea that this is due to a stoppage of the phosphorescence is hardly tenable in view of the dark spaces observed at ordinary temperatures. The probable explanation is that the increase of temperature brings about an increase in the conductivity, and a consequent reduction of the potential gradient. This is corroborated by the fact known for some time, that in a stratified discharge, the dark portions are the portions of minimum potential gradient. E. E. F.

96. *Sensibility of Spectroscopy.* **F. Emich.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 411–414, May, 1900.)—By employing Geissler tubes containing hydrogen and a mixture of oxygen and hydrogen at very low pressures, the author has found that masses of hydrogen as small as 7×10^{-14} milligrammes may still be recognised by the red spectral line. J. B. H.

97. *Ionisation by Ultra-Violet Light.* **P. Lenard.** (Ann. d. Physik, 3. 2. pp. 298–319, Oct., 1900.)—The author measures the velocity of ions produced by ultra-violet light by forcing a current of air through two flat nets in succession. The nets are made of linen threads rendered conducting by means of soap solution. The space between them is illuminated by ultra-violet light, taking care, however, that the limit of the illuminated space is 2 cm. away from the first net, which is positively charged. The second net is put to earth. When the blast is working without the rays there is no loss of charge, but when the rays are turned on, with or without the blast, there is a loss of charge due to the ionisation of the air. As the blast increases in strength the negative ions which seek to approach the positively charged screen are blown back, and when the velocity of the air is 1·3 m. per second there is no more loss. That, therefore, is the velocity of the negative ions. With the e.m.f. used this gives 3·13 cm. per second for a potential gradient of 1 volt per centimetre. The corresponding value for the positive ions is 0·0015 cm. per second. The author obtains for *s*, the sum of the radii of the molecule and positive electron, the value 56×10^{-6} mm., or about 70 times the diameter of a molecule. This means that the positive electron consists of a large number of atoms, even if it only carries one elementary charge, *e*.

E. E. F.

98. *Electric Conduction in Gases.* **J. Stark.** (Phys. Zeitschr. 2. pp. 4–6, Oct. 6, 1900.)—Local differences in the intensity of the positive and negative current produce rarefactions and concentrations of the electric ions. In regions of concentration there is a maximum in the steepness of the potential gradient, and in regions of rarefaction there is a minimum. The accumulation of ions also produces local force charges, which modify the electric field due to the electrodes. At the minima of the potential gradient the external e.m.f. must work against the local forces, but this work is recovered in the maxima. The former state corresponds to that of an accumulator which is being charged by a current, the latter to an accumulator which discharges itself and is traversed at the same time by an external current in the same direction. Hence the kinetic energy appearing in any given portion of the gas cannot be taken as a measure of the resistance in that portion. The quantity of heat developed in the bright strata is greater than that developed in the dark strata. This is now no longer in contradiction with the fact that the resistance of the bright strata is less than that of the dark strata. E. E. F.

99. *Electrical Conductivity in Gases traversed by Kathode Rays.* **J. C. McLennan.** (Roy. Soc., Proc. 66. pp. 375–378, July 9, 1900; and Roy. Soc., Phil. Trans. 195. pp. 49–77, Nov. 3, 1900.)—The object of the experiments described was to investigate the nature of the conductivity produced in different gases when kathode rays of definite strength pass through them. The tube used for the production of kathode rays was similar to that devised by Lenard. The following are the results deduced from the experiments: (1) The conductivity impressed upon a gas by kathode rays is similar to that produced by Röntgen and uranium rays, and can be fully explained on the hypothesis that positive and negative ions are produced by the radiation throughout the volume of the gas traversed. (2) When kathode rays are allowed to fall upon insulated metallic conductors surrounded by air at atmospheric pressure: (*a*) such conductors, if initially uncharged, gain a small limiting negative charge; (*b*) positive charges are completely dissipated; (*c*) negative charges drop to a small limiting value; (*d*) the loss of charge is due to the action of the ionised air surrounding the conductor, and the value of the limiting negative charge is determined by the extent of the conduction in this air. (3) The ionisation produced in a gas by rays coming from the aluminium window in a Lenard discharge tube is due to kathode rays and not to Röntgen rays. (4) Lenard's results obtained by fluorscopic methods on the absorption of kathode rays are confirmed by a study of the ionisation these rays produce in gases. (5) When kathode rays of a given strength are passed through a gas, the number of ions produced in 1 c.c. depends only upon the density of the gas, and is independent of its chemical composition. (6) It is inferred that with rays of constant intensity the ionisation in any particular gas varies directly with the pressure. This was not verified directly by experiment on account of the great absorption of the rays by gases at ordinary pressures; but the absorption has been shown by Lenard to vary directly as the pressure and the ionisation is proportional to the absorption. (7) The relative ionisations produced by kathode rays of constant intensity in air, oxygen, nitrogen, carbon dioxide, hydrogen, and nitrous oxide, at the same pressure, are expressed by the numbers which represent their densities. (8) With kathode rays, just as with Röntgen rays, the number of ions produced in a gas bears a definite ratio to the amount of the radiant energy absorbed. J. J. S.

100. *Explanation of the Dark Kathode Space.* **W. Kaufmann.** (Deutsch. Phys. Gesell., Verh. 2. 11. pp. 137–141, 1900.)—Hertz and Goldstein have shown that the so-called "negative glowlight" (Goldstein's third kathode-layer) is closely connected with the diffusion of the kathode rays produced by gases. An attempt is here made to base an explanation of the negative glowlight and the dark kathode space upon the fact that kathode rays dissociate the gas through which they pass, and render it conducting: Inasmuch as this conductivity disappears rapidly after the discharge ceases, it must be assumed that the ions into which the gas molecules split combine again of themselves. It is further assumed that the rapidity of this combination follows the chemical law of mass-action, *i.e.*, that the number of ions combining per second per cubic centimeter is $R = an_1n_2$, where n_1 is the concentration of the positive ions, n_2 of the negative ions, and a is a constant. The validity of this law for conducting gases has been demonstrated by Rutherford (Phil. Mag. (5) 44. p. 422, 1897) and McClelland (*ib.* 45. p. 29, 1898). The explanation advanced is that the negative glowlight arises through the impact of ions during their combination (whilst the ions, before coming to rest, still execute oscillations about their position of rest). A theory based on these assumptions is sketched, and its results appear to be in accordance with observed phenomena. D. E. J.

101. *The Dark Kathode Space.* **E. Goldstein.** (Deutsch. Phys. Gesell., Verh. 2. 11. pp. 142–144, 1900.)—In spite of Kaufmann's suggested explanation [see preceding Abstract] the author adheres to the views which he has previously expressed [Abstract No. 456 (1899)] as to the meaning of the dark kathode space. The glowlight (so-called third layer) consists of rectilinear rays. These do not spring from the kathode itself, but from the ordinary kathode rays (K_1-rays)—from all parts of these rays and in all directions. At first sight the existence of the "dark kathode space" seems to tell against this view. For as the K_1-rays also pass through the (apparently) dark kathode space, one would expect the glowlight to appear in it.

It is known, however, that a kathode exerts a repulsion (deflexion) upon all magnetically deformable rays, and the rays which constitute the glowlight ("glow-rays") are such. Now suppose, to begin with, that glow-rays actually proceeded from all points of the K_2-rays, including those lying nearest to the kathode. These would be repelled for a given distance from the kathode, until the repulsion for such rays became ineffective. We should thus have formed around the kathode a space free from glow-rays—the so-called dark kathode space. The author considers that this view explains most of the phenomena known in connection with the dark space. It explains how its form varies with the form of the kathode: one has only to assume that each kathode element exerts a repulsion in the direction in which it radiates. Further applications of the principle explain the extension of the dark space when the pressure diminishes; also its restriction by placing another kathode opposite, or by the action of a magnet. D. E. J.

102. *Dimensions of the Dark Kathode Space in Different Gases.* **H. Ebert.** (Deutsch. Phys. Gesell., Verh. 2. 9. pp. 99–106, 1900.)—In a previous investigation [Abstract No. 1897 (1899)] the author has shown that the thickness of this dark space adjoining the luminous kathode-layer (Hittorf's dark kathode space or the second Goldstein kathode-layer) can be expressed by the relation $d \, . \, p^m = d_0$, where p is the pressure, and m (< 1) and d_0 are constants which are characteristic for the given gas and the conditions of the discharge. He is now engaged in investigating monatomic gases, and meanwhile reports further on diatomic gases as follows:—(1) So long as the pressure is comparatively high and the kathode is not wholly covered with glowlight, the exponent m is large. It can even attain to unity: the thickness of the dark space is then inversely proportional to the pressure. (2) As soon as the electrode-plate is covered with the glowlight, d increases more slowly with increasing p (*i.e.*, m becomes smaller). For the same plate (aluminium, 1 cm. radius and 0·51 mm. thick) the following mean values of m were obtained:—H_2, 0·55; CO, 0·60; N_2, 0·57; CO_2, 0·52; air, 0·49; O_2, 0·46. It is noticeable that they group themselves about the number $\frac{1}{2}$; if they had exactly this value, the law of increase would be given by the relation—

$$d_1 : d_2 = \sqrt{p_2} : \sqrt{p_1}.$$

The values of the other constant d_0 (the thickness when $p = 1$ mm.) show more considerable differences. Thus for the above plate the values were:—H_2, 2·91; Co, 2·49; N_2, 2·21; Co_2, 2·08; air, 1·97; O_2, 1·80. The gases are here arranged according to the thickness of the dark space. The mixture air stands between its constituents N_2 and O_2; CO_2, which is shown by the spectroscope to decompose into CO and O, stands between these gases. (3) As the pressure gradually diminishes, when the dark space has attained a certain thickness Δ, m suddenly attains a larger value. The values of Δ corresponding to this sudden change lie between 2 and 2·2, and the corresponding pressures are as follows:—H_2, 2·0; CO, 1·3; N_2, 1·0; CO_2, 1·1; air, 0·9; O_2, 0·7. The pressure of the mixture air is $(\frac{4}{5} \times 1{\cdot}0) + (\frac{1}{5} \times 0{\cdot}7) = 0{\cdot}9$. (4) At still lower pressures the relation $d \, . \, p^m = d_0$ again holds good, the values of m varying from 0·97 (H_2) to 0·78 (O_2). The paper concludes with a theoretical discussion as to the physical significance of m and d_0. D. E. J.

103. *Photo-Electric Rays.* **E. Merritt** and **O. M. Stewart.** (Phys. Rev. 11. pp. 230–250, Oct., 1900.)—The authors trace the connection between kathode rays and the particles discharged from negatively charged bodies under the influence of ultra-violet light. For simplicity the authors call the

streams of particles discharged through the influence of ultra-violet light "photo-electric rays," and they then proceed to show that they are of essentially the same nature as kathode rays. This is the conclusion already arrived at by J. J. Thomson, who has even determined the ratio l/m for these rays, and found it to lie between $5{\cdot}8 \times 10^6$ and $8{\cdot}5 \times 10^6$. The authors employed an arc lamp in place of a spark-gap as a source of ultra-violet light, and their vacuum tubes were essentially the same as Lenard's, with a slanting side-tube to direct the ultra-violet rays on to the kathode. Their magnetic-deflection experiments led them to the conclusion that two kinds of particles are concerned in the photo-electric discharge: (1) The small rapidly moving corpuscles of the photo-electric rays, forming a fairly compact stream normal to the kathode; (2) the relatively heavy and slowly moving negative ions, which form a stream having the same general direction as the photo-electric rays, but much more diffuse and not appreciably affected by a magnetic field. E. E. F.

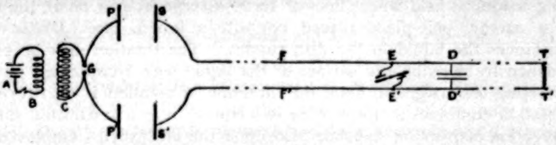
104. *Effect of Electrical Stimulus on Inorganic and Living Substances.* **J. C. Bose.** (Electrician, 45. pp. 774–777, Sept. 14; 864–865, Sept. 28; and 897–901, Oct. 5, 1900. Paper read before the British Association.)—The effects of electric radiation upon certain substances show that the changes produced, as in the coherer, are of the nature of a molecular strain. The strain may be purely elastic, or may lead to a molecular rearrangement, such as produces the change of allotropic form in phosphorus. A very perfect instance of molecular elasticity is presented by lead bromide. A coherer containing that substance shows galvanometer deflections varying with the intensity of the radiation and even with every flicker in the exciter. Absence of response or "fatigue" is due to the overstrained condition of the substance. Fe_3O_4, owing to its chemical stability, offers a good case of rapid recovery. The author reproduces a curve showing the effect of an instantaneous flash of electric radiation upon a coherer containing Fe_3O_4, and also a curve showing the response of a muscle to electrical stimulus. The aspect of the two curves is very similar. The muscular curve shows several waves of elastic after-vibration, such as is known to take place in the case of the retina. This after-vibration is also noticed in the case of certain sensitive inorganic substances. The various effects produced on muscles under intermittent stimulation are absolutely identical with those of the inorganic substance Fe_3O_4.

Further parallelisms may be shown to exist between living and dead matter in the influence of temperature in increasing the sensitiveness and facilitating the recovery of a coherer and a muscle respectively, the similar effects of fatigue in the two cases, and the effect of adding small proportions of a foreign substance or "poison." The curves representing these different effects are very similar in the two cases. The author finally proceeds to bridge the gap between purely physical and physiological processes by tracing the development of memory, the most distinctive attribute of the living organism, from the phenomenon of "recurring after-effect." The latter is a physiological phenomenon of the retina which has its counterpart in the oscillations of conductivity presented by a coherer containing magnetic oxide of iron after it has been exposed to radiation. The latter even shows a "tetanic effect," consisting of short and rapid oscillations about the maximum conductivity. E. E. F.

105. *Reflection and Transmission by Condensers of Electric Waves along Wires.* **E. H. Barton** and **L. Lownds.** (Phil. Mag. 50. pp. 357–392, Oct., 1900.

Paper read before the Physical Society of London.)—If an electric current travels along a wire and a condenser be interposed the wave is partly reflected and partly transmitted, and with difference of phase in either case. The mathematical theory of the reflected and transmitted waves is given by O. Heaviside, whose work in the main the present writers follow. The existence of the reflexion was proved experimentally by Geitler (Wied. Ann. 49. pp. 184–195, 1893.)

The writers arranged an apparatus for observing the reflected wave trains. It is shown in the following diagram :—



Here A is the battery, B and C are the primary and secondary coils, G the spark-gap. The line is represented by SEDTT′E′S′, and consists of two parallel copper wires. EE′ is the electrometer which has a single plane needle initially unchanged, and suspended by a fine quartz fibre between two discs attached to the line at E and E′. It is shown that the reflexion of waves at the electrometer, regarded as itself a condenser, is negligible. TT′ is the terminal bridge which absorbs the waves on arrival at the end of the line. DD′ is one of the condensers used to reflect the waves. In the experiments these condensers were placed at different parts of the line. For instance, in observing the transmitted system they are inserted at FF′. The waves generated by the primary oscillator undergo rapid damping, so that the tail, after ten or twelve waves, is almost negligible.

The theory is then given on the hypothesis that the circuit is what Heaviside terms a distortionless circuit. The actual experiments are then described and the results compared with theory. The writers acknowledge their obligation to Heaviside, both in respect of the general theory and for special help in the present paper. S. H. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

106. *Static Charges in Magnetic Fields.* **V. Crémieu.** (Comptes Rendus, 131. pp. 578–581, Oct. 8, 1900.)—Lippmann applied the principle of the conservation of energy to the experiments of Rowland upon electric convection, and showed that, according to his view, changes of magnetic induction ought to produce movements of electrified bodies in the magnetic field. The movement should be proportional to $\mu \frac{dH}{dt}$, where μ is the charge on the suspended body, and $\frac{dH}{dt}$ the rate of change of magnetic induction. The direction of the movement should be the same as that of a current induced in a wire situated along the trajectory of the moving body, under the same magnetic influences. Lodge published (Phil. Mag., p. 469, 1889) an account of experimental work which left the proof of the movements uncertain. Crémieu now describes researches made with a pivoted aluminium disc, separated into two parts by mica, and free to turn in its own plane in a magnetic field. This apparatus should have produced a movement of a spot of light of about

120 mm., as calculated from the dimensions of the parts and the values of $\mu \frac{dH}{dt}$. But no movement whatever was observed. The author concludes that there is no displacement of a charged body due to magnetic influences in such a direction. R. A.

107. *Motion of Electrolytes in a Magnetic Field.* **O. Urbasch.** (Zeitschr. Elektrochem. 7. pp. 114-117, Sept. 6, 1900.)—Two different electrolytes are poured into a flat dish, one above the other, say concentrated and dilute sulphuric acid, or concentrated $CuCl_2$ and HCl, and the dish is brought into a strong magnetic field whose lines of force diverge from a point, the point being a narrow pole-piece placed opposite a broad one. Under these circumstances the liquid in the dish rotates. The rotation may be placed in evidence by strewing the surface of the liquid with lycopodium powder. On reversing the magnetic field, the direction of rotation is also reversed. The rotation continues as long as the two liquids have a separating surface. The direction of rotation depends also upon the electrolytes employed. If dilute HCl over $CuCl_2$ is replaced by concentrated HCl, the direction of rotation is reversed, and at certain ionic concentrations no rotation at all takes place. The explanation is based upon the wandering of the ions across the dividing surface, near which a magnetic circular field is generated by the surplus energy of the faster ions. This circular field, acted upon by the divergent field, produces the rotation observed. Rotation also takes place when a metallic plate, covered on one side with paraffin, is brought into a solvent. In the case of zinc immersed in $CuSO_4$ the circumferential velocity may attain 5 to 10 cm. per second. E. E. F.

108. *Change of Resistance in Iron by Magnetisation.* **A. Gray** and **E. Taylor Jones.** (Roy. Soc., Proc. 67. pp. 208-215, Oct. 31, 1900.)—The difference of the fractional increments of resistance of two coils of iron wire, placed in the same magnetic field so as to have the wire of one of the coils magnetised longitudinally and of the other transversely, is here determined as a function of the strength of field and also of the intensity of magnetisation. Owing to the very large demagnetising factor for a wire magnetised transversely the intensity of magnetisation in its case is very small.

The fields were produced by means of a solenoid 1 metre long, furnished with a double cylindrical core through which a flow of water could be maintained to secure a constant temperature. The two iron wire resistances were wound non-inductively, the one longitudinally, the other transversely, on a rod of wood 60 cm. long, which was placed centrally in the axis of the solenoid during the resistance experiments. A Wheatstone's bridge arrangement was used to compare the resistances.

To determine the intensity of magnetisation of the longitudinally magnetised wire as a function of the field, a number of pieces of the same wire were placed side by side in a glass tube on which a small ballistic coil was wound. The tube was placed in the solenoid, and a B-H curve determined ballistically by reversals of the current in the solenoid.

The increase of resistance of the coil magnetised longitudinally is always the greater. If P and Q are the resistances of the two coils, then

$$\Delta\phi \equiv \frac{\Delta P}{P} - \frac{\Delta Q}{Q}$$

is measured as a function of H. The curves representing $\Delta\phi$ as a function of B^2 and I^2 are approximately straight lines. J. B. H.

109. *Measurement of Galvanometer Resistance.* **W. S. Day.** (Phys. Rev. 11. pp. 251–254, Oct., 1900.)—The method proposed is to vary the potential difference on the terminals of the galvanometer and measure the additional resistance required to be inserted to maintain the deflection constant. The potential difference is obtained on a bridge wire through which a steady current is maintained. If three readings be taken embracing resistances of the bridge wire proportional to 1, 2, and 3, the galvanometer resistance is $3a - b$, where a and b are the resistances inserted to maintain the deflection constant in the two latter cases. If the bridge wire resistance is negligible compared with that of the galvanometer, two readings are sufficient, and if these embrace resistances proportional to l and $l + m$, $g = \frac{l}{m} a$. G. H. B.

110. *Measurement of High Resistance.* **O. N. Rood.** (Amer. Journ. Sci. 10. pp. 285–294, Oct., 1900.)—In the method adopted for measuring high resistances the electricity is allowed to slowly accumulate till it reaches a certain potential. The apparatus employed was a modification of a single leaf electroscope which served as an electrometer. A brass rod was supported on a bar of ebonite which was placed on two rods of the same substance fastened on a base of ebonite. The rods and the bar were painted with melted resin. The rod carried an aluminium leaf, bluntly pointed below and attached above by a gold-leaf hinge. Opposite to the lower part of the aluminium leaf at a short distance was fixed a plate of sheet brass faced with platinum-foil; this received the charge from the aluminium leaf when its potential was sufficiently raised. The distance of the plate from the leaf could be varied by a micrometer screw.

A sealed glass tube 130 cm. in length was made to establish connection between a Leyden jar charged to a potential of 12,000 volts and the electrometer. In this case the electricity advanced slowly over the entire length of the tube, the electrometer not being at all effected for some time. In about five minutes it gave regular strokes; the tube had assumed the stationary condition, and had nearly the same potential over its whole length except near the electrometer, where for 3 or 4 cm. it was lower. For half an heur it was allowed to deliver charges to the electrometer with much regularity, the rate being observed with a stop-watch.

After the construction of a set of units of high resistance, the resistance of a tube of soft German glass 27 cm. in length, which had been for some days in a box dried with sulphuric acid, was measured. This was found to be 250,000 megohms. Under the influence of the current at 110–112 volts it increased to 380,000 megohms, the hygrometer indicating 43 per cent. of moisture. On a later day, when the hygrometer indicated 53 per cent., the resistance of the tube had fallen to 180,000 megohms.

The results of experiments on silk, paraffin paper, mica, jade, guttapercha, black sealing-wax, ebonite, amber, and resin are also given. In the case of ebonite in dry weather inductive effects occurred, and if the ebonite conducted at all in the regular way, such conduction was masked by the inductive effects. J. J. S.

111. *Electrical Properties of Glass.* Part. II. **A. Gray** and **J. J. Dobbie.** (Roy. Soc., Proc. 67. pp. 197–207, Oct. 31, 1900.)—An account is given of the continuation of experiments formerly described [see Abstract No. 808 (1898)] on the electrical qualities of specimens of glass of which the chemical composition was determined by analysis. In this paper the results of further experiments on eight different kinds of glass are given in a table which contains the percentage composition of the specimens and their specific resistance and specific inductive capacity at different temperatures. It appears that potash glasses have very much higher resistances than soda glasses. In one case the substitution of soda for potash in the composition of the glass was found to diminish the resistance of the glass to $\frac{1}{130}$ of its former amount. It was found that the effect of annealing glass is very greatly to increase its specific resistance. In the case of lead-soda glass the specific resistance was raised to three times its former value. Annealed glass is therefore a much better insulator than unannealed glass. J. J. S.

112. *Stability of Temperature in an Electric Conductor.* **H. E. Wimperis.** (Electrician, 45. pp. 929–930, Oct. 12, 1900.)—As the electrical resistance of most metals increases with the temperature according to a nearly linear law, the author thought that there might occur cases of possible instability of temperature when the conductor carried a constant current. In the case of a wire of some conducting metal carrying a constant current, let the temperature of some small portion be raised (by a flame, for instance), the resistance of this portion is increased, and therefore the heat generated at this portion by the current will be greater, and the temperature will tend to rise still further. There are two phenomena that tend to oppose this rise of temperature; they are increased radiation and the fact that heat is conducted away from this portion through the wire itself. The latter result can be made very small by suitably designing the wire. Whether or no the temperature of the small treated portion will rise or fall on removing the flame will depend on which is greater, the increase of heat owing to the increase in resistance or the decrease of heat due to increased radiation. If two curves are plotted, the abscissæ being temperatures and the ordinates heat gained or lost per second at those respective temperatures, the first curve being heat gained due to the current and the second heat lost due to radiation, where the curves cut one another will obviously be the equilibrium point of temperature. If the slope of the radiation curve is greater than that of the current curve at the point where they cut one another, the temperature will be stable; if the reverse, it will be unstable. Finally, it is found that instability is impossible with any metal known, since the law connecting the resistance of a metal and temperature is nearly linear and the radiation curve is convex to the axis of temperature. E. C. R.

113. *Neutral Point of Thermo-couples.* **A. Abt.** (Ann. d. Physik, 3. 2. pp. 320–327, Oct., 1900.)—The author describes a simple method of determining the neutral point in thermocouples, which is specially suited to demonstration purposes. It is based upon the equation—

$$E = (t_1 - t_2)\left[a + b(t_1 + t_2)\right]$$

The temperatures of the junctions are changed until the current disappears. When that occurs, the neutral point is the arithmetical mean of the temperatures t_1 and t_2 of the junctions respectively. The arrangement as described consists of two wooden frames with openings closed by plates of asbestos, one on each face of the frame. Holes are bored in the plate, and thick steel rods are inserted through the holes. One end of each rod contains receptacles for the bulb of a thermometer and one for junction of the thermocouple, while the other is heated by a Bunsen flame. Images of the thermometers and of the galvanometer scale are thrown upon a screen, and the heating is carried on until the current disappears, or until it reaches a maximum, while one junction is kept at the temperature of the room. The neutral point is 117° in a brass-lead couple, 276·8° in an iron-silver couple, and 282° in an iron-zinc couple. E. E. F.

114. *Thermo-magnetic Phenomena.* **G. Moreau.** (Journ. de Physique, 9. pp. 497–506, Sept., 1900.)—The author interprets the thermo-magnetic effect of Nernst by regarding it as a Hall effect of the electromotive forces that Kelvin introduced into his theory of thermoelectric currents. The behaviour of nickel appears to be anomalous. If it is supposed that, in the case of nickel, Thomson's coefficient, σ (the specific heat of electricity), does not equal the e.m.f. of true contact, it may perhaps be stated in general that the thermo-magnetic effect is a Hall effect of the true contact electromotive force of Thomson. [See Abstracts Nos. 860 and 1454 (1900)]. J. J. S.

115. *Thermoelectricity of Electrolytes.* **A. H. Bucherer.** (Ann. d. Physik, 3. 2. pp. 204–209, Oct., 1900.)—Starting from van't Hoff's osmotic pressure formula,

$$VdP = vdp,$$

the author arrives at the equation

$$E = \frac{4\cdot35 \times 10^{-5}}{\gamma}\int_{T_1}^{T_2}(2N-1)\,R\,dT,$$

where γ is the number of valencies with which the metallic element of the electrolyte is bound to the non-metallic element. The same equation has been derived by Duane from Nernst's theory. E. E. F.

116. *Electric Effect of Light upon Green Leaves.* **A. D. Waller.** (Roy. Soc., Proc. 67. pp. 129–137, Oct. 26, 1900.)—Under certain favourable conditions, which are not as yet completely determined, green leaves show a true electrical response to light, consisting in the establishment of a potential difference between the illuminated and the non-illuminated half of a leaf which may amount to 0·02 volt. This effect shows a remarkable similarity with the effect of electric excitation upon nerve and muscle. In the human nerve substance, electric excitation causes a current from the resting to the active tissue, followed after a few seconds by a smaller current in the opposite direction. In iris leaves, the current flows from the illuminated to the shaded half of the leaf during illumination, and in the opposite direction for about five minutes after the illumination has ceased. The response takes about four seconds to set in, and it is only the young and growing leaves that show any response. When the stimulus is repeated, a certain amount of fatigue is shown, as in all organic structures and even in some inorganic substances. But no fatigue is shown when the leaf is given an hour to recover between each stimulus. The tobacco plant acts like iris, but in tropæolum and other plants the currents are in the opposite direction. That chlorophyll is essential to this photo-electric reaction is shown by the fact that the petals of flowers do not show it. E. E. F.

117. *Determination of Frequency.* **A. Samojloff.** (Ann. d. Physik, 3. 2. pp. 353–354, Oct., 1900.)—The author describes a very simple method of determining the frequency of an alternating electric light current. In the course of some physiological experiments on the intermittent excitation of the

retina, made with a disc consisting of black and white sectors, he noticed that on illuminating it by a glow-lamp the disc appeared to stand still when revolving at a certain rate. That rate was the rate at which the alternations of black and white at any given point of the disc were synchronous with the alternations of the luminosity. The periodical partial extinctions of the filament, though imperceptible to the eye, were evidently sufficient to make the intermediate grades between a maximum or minimum of whiteness disappear, and thus to produce the appearance of a disc at rest. Hence it is only necessary to place a revolving disc near the lamp and to alter its speed until it appears to stand still. The number of white sectors, multiplied by the revolutions per second, gives the number of reversals per second of the current. The frequency of a Wehnelt interrupter may be similarly determined by mounting it in parallel with an arc lamp and treating the latter as an alternate-current lamp. This may be done in daylight. E. E. F.

118. *Light Emitted by Continuous-Current Arc.* **Mrs. H. Ayrton.** (Electrician, 45. pp. 921–924, Oct. 12; and 966–967, Oct. 19, 1900. Abstract of a paper read before the International Electricity Congress at Paris.)—With constant current there is a definite length of arc at which the candle-power is a maximum; when the current exceeds 10 amperes there is also a minimum point, corresponding to a length of arc of about 2 mm., and there is another maximum point at about 1 mm. The last is shown to be due to the shape of the point of the negative carbon, which permits more light to escape from the crater when the arc is 1 mm. in length than when it is 2 mm. long. At the same time the efficiency is greater, and it is shown that no other length of arc is equally efficient. The ideal arc is exceedingly short, with a very sharp-pointed negative carbon. The increase in candle-power between the minimum point and the second maximum is due to the diminished screening by the negative carbon; but the subsequent diminution can only be due to absorption by solid particles of carbon and carbon vapour in the arc itself. This was proved by throwing the shadow of an arc upon a screen by means of a second arc; the same experiment showed that the arc is less dense than air, and acts as a negative lens. The increased absorption is caused by the greater condensation of carbon vapour between the carbons as the arc is lengthened. The absorption is shown to be selective, the carbon mist absorbing a larger proportion of the orange and green than of the violet rays. This explains the violet tint of the light emitted by the arc itself, the tendency of the light to become more violet as the arc is lengthened, and the diminution of the candle-power in the latter case. A. H. A.

119. *Cable Tests at High Voltages.* **J. Wright.** (Elect. Rev. 47. pp. 653–654, Oct. 26, 1900.)—The author thinks that a wire insulated with vulcanised rubber may show many hundred megohms when measured with 600 volts continuous pressure, and break down immediately under 600 volts alternating. Insulation should be taken immediately before and after high-pressure tests, and *no* diminution found. M. O'G.

120. *Measurement of Standard Resistances.* **R. T. Glazebrook.** (Phil. Mag. 50. pp. 410–416, Oct., 1900. Paper read before the Physical Society of London.)—This paper gives a description and comparison of four different methods of determining the resistances of coils of 10, 100, and 1,000 ohms. Each coil was determined by two or more methods, and the results show the accuracy that may be obtained without any very elaborate precautions. The

coils were all of platinum silver with a temperature coefficient of about 0·00028 per 1° C., and by far the most important source of error is the uncertainty of the temperature. In Method I. (which was that employed in constructing the standards of the British Association), three 3-ohm coils are wound on the same bobbin and adjusted to be as nearly equal as possible. By means of an arrangement of mercury cups these coils can be put in parallel or in series. If B is their resistance in parallel and B′ that in series, $B' = 9B$ very approximately.

Let U be the resistance of the short copper rods used to connect the system of coils to a Carey-Foster bridge, X the resistance of the 10-ohm coil to be found, and S the resistance of the standard ohm. The coils are first put in parallel and compared with S; let x be the shift on the bridge wire. Then $B + U = S + x$. Next S is placed in series with the three 3-ohm coils, which are also in series, and these are compared with the 10-ohm coil. In this case let x_2 be the shift on the wire. Then

$$X = 9B + U + S + x_2 = 10S - 8U + 9x + x_2,$$

so that if U is known, the value of X is found in terms of S.

The other methods are "built-up" ones. Five coils in series are enclosed in a box, their values being 1, 1, 2, and 4 units. The two ends of the whole series, and each junction of two consecutive coils, are connected to mercury cups.

Method II. The two unit coils of the box are separately compared with the standard by connecting it to a Carey-Foster bridge with contact pieces of known resistance. The other coils are found in terms of these, so that ultimately the value of the whole box is known in terms of the standard. The objection to this method is that it takes time, and temperature changes lead to difficulty.

Method III. This is a preferable method for boxes where the unit coil is greater than 1 ohm. Two 10-ohm coils, P and Q, have their difference accurately found by the Carey-Foster bridge; thus the ratio P/Q is accurately known. The value of the first unit coil of the box is also found on the Carey-Foster bridge. Four mercury cups, A, B, C, and D, are arranged at the corners of a square, the gaps A B, B C contain the coils P, Q respectively. The first unit coil of the box is connected to A and D, and the second to D and C. The resistances of the connecting-rods should be equal. A battery connects B and D, and a galvanometer A and C.

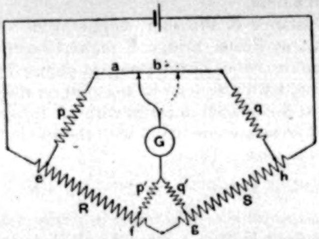
A balance is obtained by shunting P or Q with a resistance W, which need not be accurately known. Thus the second unit coil is obtained in terms of the first. These two in series are then compared with the 2-unit coil and so on. A table of comparisons of certain standard 10-ohm coils is given, each coil being determined by two at least of the above methods.

The difference between the values obtained for the same coil by two different methods does not exceed 0·00004 of the whole value, and in most cases is not greater than would be caused by an uncertainty of 0·1° C. in temperature, and no attempt was made to read the thermometers to a greater accuracy than this.

In the case of the 100 and 1,000-ohm coils Method III. was used; also a fourth method, viz., that ordinarily employed in testing such coils for the B.A. Committee. E. C. R.

121. *Improved Form of Carey-Foster Bridge.* **C. V. Drysdale.** (Electrician, 45. pp. 883–886, Oct. , 1900.)—This bridge is a combination of the secondary

conductors of the Kelvin double bridge with the Carey-Foster bridge, so as to adapt the latter for use in the measurement of very low resistances. For this purpose, in addition to connecting the secondary conductors or ratio coils across the junction between the resistances to be compared, the slide-wire is removed from its ordinary position between the coils whose resistances are to be compared, and introduced between the ordinary ratio coils as indicated in the figure.



In this arrangement, if x is the resistance between terminals f and g, including the contact resistance, and C_1 and C_2 the currents in the upper and lower branches respectively, we have

$$R + \frac{p'}{p'+q'}\left\{\frac{x(p'+q')}{p'+q'+x}\right\} = R + \frac{p'x}{p'+q'+x} = \frac{C_1}{C_2}(p+a),$$

and on interchanging R and S,

$$S + \frac{p'x}{p'+q'+x} = \frac{C_1}{C_2}(p+a+b);$$

hence—

$$R - S = \frac{C_1}{C_2}b.$$

A practical form of the bridge is described possessing the following novel features, viz.: (*a*) The copper connecting bars are all mounted *beneath* the ebonite base, and have mercury cups projecting through so as to be level with the upper surface of the ebonite; (*b*) the slide-wire is always connected between the ratio coils, thus reducing the number of contacts on the commutator to four; (*c*) the cups for the secondary conductors or ratio coils can be readily short-circuited so as to adapt the bridge for ordinary use; (*d*) the sliding contact is mounted on an arm which is pivoted at the other end.

C. K. F.

122. *Resistances of Platino-Silicium.* **V. Rodt.** (Elektrotechn. Zeitschr. 21. pp. 847–848, Oct. 11, 1900.)—The firm of W. C. Heraeus, of Hanau, has recently placed on the market resistances consisting of a thin layer of platino-silicium spread over a cylindrical core of clay (about 7·2 to 12·1 cm. long and 0·5 cm. in diameter). Originally these resistances were intended for electric heating appliances. The author's investigations show that they are wonderfully permanent, and are capable of withstanding exceedingly rough treatment. Heating to a high temperature in the flame of a Bunsen burner, exposure to the fumes of bromine for a period of eighteen hours, soaking for a long time in brine or in nitric acid, appeared to produce no perceptible change in the value of the resistance. Hence such resistances are particularly well adapted for use in all cases where the ordinary wire resistances are liable to be attacked by chemical agency. [See also Abstract No. 175 (1900).] A. H.

123. *Standard Resistance Coil.* **R. S. Whipple.** (Electrician, 45. p. 772, Sept. 14, 1900. Paper read before the British Association.)—The coil described is made of bare 0·085-inch platinum silver wire wound on mica frames, the ends of the wire being attached to stout copper terminals in the usual manner. A 0·008-inch platinum wire is wound alternately with the platinum-silver wire, and is also attached to stout copper leads. Both coils are adjusted to a resistance of 1 ohm at 15·5° C. Owing to the difference in the temperature coefficient in the two wires a small change in the temperature causes a comparatively large difference between the resistances of the two coils. From this difference the temperature may be determined from a table experimentally made up beforehand. The frame and wires are immersed in oil contained in a glass vessel. They are therefore at the same temperature, and since they are wound alternately no stirrer is necessary. The platinum wire is also useful for testing the insulation of the windings of the Pt-Ag coil one from the other. E. E. F.

124. *Construction of Standard Resistances.* **M. T. Edelmann.** (Elektrotechn. Zeitschr. 21. pp. 807–808, Sept. 27, 1900.)—The resistances here described are made of manganin heated for some time to 100° C. in steam-jacketed vessels to prevent subsequent alteration, and coated with shellac to protect them from the action of the atmosphere. The coils are wound on old maple bobbins saturated with shellac varnish and well dried before and after varnishing. The coils are provided with Uppenborn's correcting shunt as follows: The first, or main section, consists of a thick double silk covered wire treated with shellac and wound double, its ends being soldered with silver into metal plates mounted on one end of the bobbin. This wire is in one piece, and its resistance is about 1 per cent. higher than the standard. The shunt has its ends soldered with acid-free solder on to the plates and is more than 100 times the resistance of the thick wire. The inner part of this coil is divided and the ends screwed to a block on the lower end of the bobbin. The combined resistance is then adjusted to the normal value by means of the correcting coil, taking care not to cut off too much, as unsatisfactory results are obtained if joints are made. Each of the plates is joined to its respective plug-block by a separate pillar instead of joining the ends of two adjacent coils to a common pillar as heretofore, thus eliminating the error due to there being a varying number of these pillars in circuit according as consecutive resistances are in use or not. In calibrating, the plugs are inserted very tightly by means of keys similar to those used in tuning pianofortes, the plugs being made wholly of metal so as to resist the extra stress. By this means the resistance of thirty plug-joints in series is ± 0·00003 ohm with 7 mm. plugs; with 14 mm. plugs it is ± 0·000005 ohm. C. K. F.

125. *Cable Capacity Measurements.* **J. E. Young.** (Inst. Elect. Engin., Journ. 29. pp. 941–943, July, 1900.)—The "instantaneous" or "surface" capacity is a constant, and the "total" capacity depends on the time of charge. "Murphy's" method gives an intermediate or quasi-constant measure, but has been found best for securing uniformity of measurement. M. O'G.

126. *E.M.F. produced by Movement of Liquid.* **C. Zakrzewski.** (Accad. Sci. Cracovie, Bull. pp. 224–227, June, 1900.)—Water was caused, by means of compressed air, to pass from one vessel to another through a capillary glass

tube silvered inside. The length of the tube was about 15 cm., its diameter 0·2 mm. Two platinum electrodes covered with platinum black were placed opposite the ends of the capillary tube, and were joined to wires of the same metal, which passed outside and could be connected to a Thomson's astatic galvanometer. It was found that a flow of water was always accompanied by an electric current, whose direction depended on that of the water.

(1) The E.M.F. of this current was found to be proportional to the difference of pressures at the two ends of the capillary tube. In one series of observations the following numbers were obtained :—

Pressure in Atmospheres (P)	E.M.F. in Volts (E)	Ratio $\frac{E}{P}$
0·5	0·026	0·0052
0·6	0·031	0·0051
0·8	0·043	0·0054

(2) The E.M.F. depends on the distance between the electrodes and the ends of the capillary tube. Increasing the distance of the electrode in the vessel at lower pressure diminishes the E.M.F.

This result may be considered as a confirmation of the Quincke-Helmholtz hypothesis, which explains the origin of the E.M.F. by the disruption of the double electric layer situated at the surface of separation of silver and water. A second charge must be admitted in the layer of silver. If one of the platinum electrodes is taken away and the galvanometer directly connected to the layer of silver, an electric current is observed when the flow of water is directed towards the electrode. The E.M.F. diminishes as the electrode is moved farther away. If the flow of water is in the opposite direction the current is much more feeble. In this case nearly all the electrified particles are dispersed in the vessel, and it is only a very small number of them which pass through the tube and give up their charge to the layer of silver.

Sometimes, especially in tubes newly silvered, the E.M.F. undergoes sudden changes, rising from some thousandths to some tenths of a volt, or *vice versâ*. This is due to change of resistance of the tube and its contents. It may almost always be brought back to its original value by causing electric sparks to pass in the neighbourhood of the tube. The tube with the contained liquid behaves in this case like a coherer towards electric waves.

The E.M.F. becomes less as the thickness of the layer of silver is increased.

In experiments with water the electrode in the vessel at lower pressure is always positive, which shows that water in contact with silver has a positive charge. When a dilute solution of silver nitrate is used instead of water it is found that the sign of the charge of the solution depends on its concentration.

J. J. S.

127. *Resistance of Pressed Powders.* **F. Streintz.** (Ann. d. Physik, 3. 1. pp. 1–19, Sept., 1900. From the Akad. Wiss. Wien, Sitz. Ber. 109. IIa., April, 1900.)—The distinction between metallic and electrolytic conduction is chiefly based upon the temperature coefficient of the resistance. If the resistance increases with the temperature, the conduction is metallic. If it decreases, the conduction is electrolytic. Conductors belonging to both classes, or to an intermediate class, have not hitherto been obtained. But the author has made some experiments on powdered conductors which indicate something like a transition from one class to the other. He prepared fine powders of platinum black, graphite, and lampblack, and subjected them to considerable pressure in a hole bored in a block of ebonite, at the same time determining their resistance by auxiliary electrodes inserted in the block. The resistance of 1 mm. of platinum black having a section 1 mm. square was found to be 0·92 ohms at zero, as against 0·14 for ordinary metallic platinum. But the temperature coefficient of platinum black is only half that of platinum. Lampblack under the same conditions showed a resistance of 40,000 ohms, and a *negative* temperature coefficient amounting to the enormous value of 1 per cent. for 1° C. The column of lampblack is therefore equivalent to a dilute solution of sulphuric acid. Graphite, on the other hand, showed a resistance of only 21·9 ohms, and had a positive temperature coefficient. It therefore ranges itself among the metals in this respect. To complete the electrolytic character of lampblack, some kind of ionisation and consequent polarisation remains to be established. E. E. F.

128. *Measurement of Power in Inductive Circuits.* **E. Reisz.** (Elektrotechn. Zeitschr. 21. pp. 713–714, Aug. 23, 1900.)—The method involves the use of only two measuring instruments—a voltmeter and an ammeter—and a standard non-inductive resistance. In Fig. 1 the coiled line between A and B represents the inductive load. If V = P.D. between A and B, i = current, $\cos\phi$ = power-factor, then the power is given by $Vi\cos\phi$. By connecting in parallel with the inductive load a non-inductive resistance NR, we obtain the following relation (Fig. 2) between i, a, and b :—

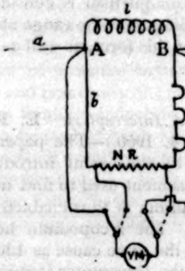


FIG. 1.

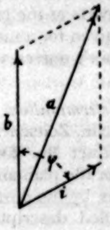


FIG. 2.

$$a^2 = b^2 + i^2 + 2bi\cos\phi \tag{1}$$

In order to find i, the shunting resistance is altered (the P.D. across AB being, however, maintained constant). Let the new values of a and b be denoted by a_1 and b_1. Then—

$$a_1^2 = b_1^2 + i^2 + 2b_1 i\cos\phi, \tag{2}$$

so that i and $\cos\phi$ may be found from (1) and (2). The author remarks that the method may prove useful in cases where the power is so small that an ordinary wattmeter is not sufficiently sensitive, and where a reflecting wattmeter is not available. A. H.

129. *Mirror Form of Electro-dynamometer.* **J. Kollert.** (Elektrotechn. Zeitschr. 21. pp. 788–794, Sept. 20, 1900.)—This is an important paper on electro-dynamometers. It is divided into four parts, of which the first deals with the instrument as a wattmeter, the second as an ammeter, the third as a voltmeter, the fourth shows the arrangement of an instrument adapted for either of these measurements. In the first part constructional details of a mirror form of wattmeter are given. It is shown that in order to adapt this instrument to general measurements of direct or alternate currents self-induction must be reduced. This implies a small turning moment, and consequently the use of a mirror. To provide a portable, self-contained instrument a telescope and scale is attached to the base-plate of the wattmeter. There are two "current" coils, each consisting of eight turns of manganin wire 1·5 mm. diameter; they are wound and set like the coils of a Gaugain-Helmholtz galvanometer, so as to provide a uniform field for the "e.m.f." coil, which hangs between them. The "e.m.f." coil consists of 260 turns of manganin wire 0·25 mm. diameter. The mean diameter of the suspended coil is 1·5 cm. Full details of the suspension and optical arrangements are given. The author then considers the problem of the error introduced by the employment of shunts, and he shows that even for high periodicities the self-induction of the instrument is so small that its readings are for all practical purposes correct. He can therefore deal with currents from 0 to 500 amperes by shunting. The correction coefficient for mutual induction between the coils, corresponding to differences of phase and frequency, are also calculated; it amounts to something like 0·5 per cent. in a moderate case. The effect of the earth's magnetism is considered. In the latter parts of the paper details of the windings and the range of measurement are given for ammeters and voltmeters of this form, as well as diagrams of the author's universal electro-dynamometer. R. A.

130. *Determination of Frequency in Liquid Interrupters.* **E. Ruhmer.** (Elektrotechn. Zeitschr. 21. pp. 824–826, Oct. 4, 1900.)—The paper referred to in Abstract No. 2041 (1900) is extended by the useful introduction of drawings of the plan and elevation of the instrument used to find interrupter frequencies by the dust-heap method. The author is thus enabled to give a more detailed description of the apparatus. The lycopodium heaps produced at each current interruption arise from the same cause as Lichtenberg figures. A measurement of the e.m.f. across the interrupter terminals when driven at 110 volts showed an increase to 205 volts, the e.m.f. at the instant of break probably amounting to thousands of volts. In order to get good dust figures the self-induction of the circuit must not be too small. G. E. A.

131. *Power-factor Indicator.* **A. J. Bowie, Jr.** (Elect. World and Engineer, 36. pp. 644–645, Oct. 27, 1900.)—The instrument will read directly the angle of lag of current behind an e.m.f. E_1 when there are known the angles of lag, α and β, of E behind two other e.m.f.'s E_1 and E_2 and the ratio E_1/E_2. It consists of a wattmeter with two movable coils mounted on the same suspension and fixed relatively to one another at an angle ϵ. To measure the lag on two-phase systems, E_1 and E_2 being the two e.m.f.'s; $\alpha = 0$, $\beta = \pm 90°$ and $E_1 = E_2$; then if ϵ be made 90° the deflection of the movable system is dependent only on the angle of lag. On three-phase systems, with triangular connection, E_1 and E_2 are taken as the e.m.f.'s on two sides of the triangle; then if ϵ be made 120° the indicator will read the angle of lag in the main from the junction of the two sides of the triangle representing E_1 and E_2, α and β in this case being each $= 30°$. On single-phase systems an auxiliary out-of-phase e.m.f. must be produced by using an inductance, but in this case the readings will vary with the frequency. G. H. B.

132. *Current Manometer.* **G. Bredig** and **O. Hahn.** (Phys. Zeitschr. 1. pp. 561–562, Sept. 8, 1900.)—The authors have arranged a gas voltameter to measure the current passing through it by the rate of evolution of gas. A voltameter filled with 2 per cent. caustic solution is provided with only a capillary outlet for the gas, and a water pressure gauge is connected with the voltameter cell. The rate of evolution of gas, which is proportional to the current, is also proportional to the pressure produced by the restricted outlet of the capillary tube, and the current is therefore proportional to the readings of the water gauge.

The sensibility can be varied within very wide limits by using capillary tubes of different bores. The authors' tests show an accuracy of about 2 per cent. G. H. B.

133. *Limiting Deflection of a Quadrant Electrometer.* **A. B. Chauveau.** (Journ. de Physique, 9. pp. 524–532, Oct., 1900.)—In measuring high potentials with the quadrant electrometer, whose sensitiveness is reduced by the employment of a heavy needle and a considerable distance between the wires of the bifilar suspension, it is found that after a certain difference of potential the sensitiveness decreases rapidly, and that the deflection attains a value beyond which it cannot go. The author points out that the existence of this limiting deviation is due to the impossibility of practically realising a perfect symmetry of the system formed by the quadrants and the needle, and to the existence of a disturbing electric couple which is proportional to the square of the difference of potential between the quadrants. The author studies, theoretically and practically, the influence of various modifications of the suspension upon the limiting deflection, and shows that, by a careful construction, the limit can be pushed back almost indefinitely, so that the deflections in one direction at all events should show no serious falling off in the sensitiveness for the higher e.m.f.'s. With his own instrument, which is now installed for use at the Eiffel Tower Observatory, he has thus succeeded in measuring voltages as high as 2,000, or even higher. E. E. F.

ALTERNATING CURRENTS AND MAGNETISM.

134. *Skin Effect and Distribution of Currents in Squirrel-Cage Rotor.* **R. Goldschmidt.** (Écl. Électr. 25. pp. 76–83, Oct. 13, 1900.)—The author deals with three alternate-current problems which have already received solutions, but only by the aid of somewhat advanced methods; and offers simple approximate methods of dealing with them. The first problem is that known as the "skin effect," and has reference to the unequal distribution of an alternating current over the cross-section of a conductor. It is assumed that the conductor is a circular cylinder, and that it is so far removed from other conductors that the field in the substance of the conductor is a symmetrical one, the lines of induction being a series of concentric circles. Imagine the conductor split up into a number of hollow concentric cylindric shells of equal thickness. Let e stand for the instantaneous p.d. across the ends of the conductor, and let r_n, r_{n+1} and i_n, i_{n+1} stand for the resistances of, and instantaneous currents in, the nth and $n+1$th shells respectively. Then (see Fig. 1) we have $i_{n+1} r_{n+1} - i_n r_n =$ total resultant e.m.f. round circuit shown by dotted lines. But if F_n and F_{n+1} stand for the total number of

lines of induction linked with the nth and $n+1$th shells respectively, then—

$$i_{n+1}r_{n+1} - i_n r_n = \left(e - 10^{-8}\frac{dF_{n+1}}{dt}\right) - \left(e - 10^{-8}\frac{dF_n}{dt}\right) = \frac{d(F_n - F_{n+1})}{dt}\cdot 10^{-8}.$$

Or, if we denote $F_n - F_{n+1}$ (the magnetic flux through the dotted line in Fig. 1) by f_{n+1},

$$i_{n+1}r_{n+1} - i_n r_n = \frac{df_{n+1}}{dt}\times 10^{-8} \qquad (1)$$

Now if R_{n+1} stand for the magnetic reluctance of the path corresponding to the flux f_{n+1}, we have

$$f_{n+1} = \frac{4\pi}{10}\cdot\frac{I_{n+1} + 0{\cdot}25 i_{n+1}}{R_{n+1}},$$

where $I_{n+1} = i_1 + i_2 + \ldots + i_n$. Substituting this value in equation (1), and putting, for the sake of brevity,

$$c_1 = \frac{r_n}{r_{n+1}},\quad c_2 = \frac{4\pi}{10}\cdot\frac{10^{-8}}{R_{n+1}r_{n+1}},$$

we get—

$$i_{n+1} = c_1 i_n + c_2\frac{dI_{n+1}}{dt} + \frac{c_2}{4}\frac{di_{n+1}}{dt} \qquad (2)$$

Next assume that all the quantities are simple sine functions of the time, and put $i_n = A_n \sin pt$, $I_{n+1} = S_{n+1}\sin(pt + \alpha)$, $i_{n+1} = A_{n+1}\sin(pt+\beta)$, then (2) becomes

$$i_{n+1} = c_1 A_n \sin pt + pS_{n+1}\cos(pt+\alpha) + \frac{pc_2}{4}A_{n+1}\cos(pt+\beta),$$

and we are now, by means of the vector diagram shown in Fig. 2, able to find i_{n+1} when i_n and I_{n+1} are known.

In applying this method we commence with the central cylinder, assuming arbitrarily any current (say unity) for it. We then find, by the vector diagram of Fig. 2, the current in the neighbouring cylindric shell. Proceeding step by step, we construct a diagram giving the relative amplitudes and phases of the currents in the various shells. From this the resistance of the cylindric conductor to the alternating current is easily found.

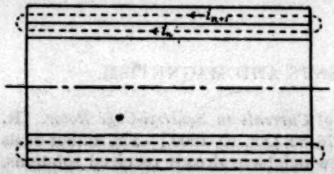


FIG 1.

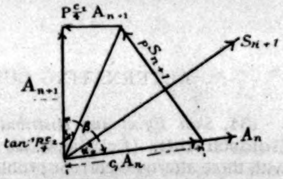


FIG. 2.

The second problem considered by the author is the screening effect due to eddy currents in plates and solid masses of iron. The treatment follows closely the method just explained for dealing with the unequal distribution of a current over the cross-section of a conductor. The last problem is concerned with the distribution of the currents in a squirrel-cage rotor when the impressed rotating field has a simple sine distribution in space. A. H.

135. *Impedance of Iron Conductors.* **C. Feldmann** and **J. Herzog.** (Elektrotechn. Zeitschr. 21. pp. 844–847, Oct. 11, 1900. Also Abstract in Elect. Engin. 26. pp. 741–743, Nov. 23, 1900.)—After referring to the work of Rayleigh and Kelvin on the distribution of an alternating current over the cross-section of a conductor, the authors point out that the series given by these writers for the equivalent resistance of the conductor, are very slowly convergent when the permeability has a high value, and that it is more convenient in such cases to have recourse to the formulæ of J. J. Thomson, for the actual magnetic intensity at any point of a lamina of iron which is subjected to an alternating impressed magnetic field. These formulæ will apply to the distribution of an alternating current over the cross-section of a lamina, and it is convenient to determine the depth of the effective surface layer which represents the equivalent resistance. Curves are given for this depth corresponding to different thicknesses of the lamina and different frequencies. The authors next give the results of some experimental determinations of the impedance for iron conductors of various forms of cross-section. The subject is of importance in connection with polyphase systems of electric traction using a rail return. An account of some further experiments with steel rails is given, which shows that the impedance varies considerably with the shape of the p.d. wave, a peaked wave producing a much higher impedance than a sine wave. Wattmeter measurements showed that the power factor was in all cases in the neighbourhood of 0·8. The authors point out that with alternating currents the efficiency of rail bonds is relatively less important, on account of the greatly increased impedance of the rails; the experiments alluded to above showing that with a frequency of 42 the impedance was 5·25 times, and with a frequency of 15, 3·6 times, the resistance to continuous currents. The importance of using the lowest practicable frequency in connection with traction systems is sufficiently obvious. A. H.

136. *Influence of Magnetism on Chemical Reactions.* **A. de Hemptinne.** (Zeitschr. Phys. Chem. 34. pp. 669–682, Sept. 18, 1900.)—The author applies the laws of thermodynamics to the study of the influence of magnetism on chemical equilibrium, and finds that even under the most favourable conditions such influence is too small to be measured. For example, the change in the heat of solution of iron in dilute hydrochloric acid brought about by a magnetic field of 10,000 units would be about 0·13 per cent. To determine the influence of magnetism on the velocity of chemical reactions, the hydrolysis of methyl acetate, the inversion of cane sugar, the action of acids on iron, and the union of hydrogen and chlorine have been studied both within and without a magnetic field. The differences between the results of the two series of experiments lie within the limits of experimental error. T. H. P.

137. *Magnetic Susceptibility and Atomic Volume.* **S. Meyer.** (Phys. Zeitschr. 1. pp. 433–434, July 7, 1900.)—Against Errera's contention that the magnetic susceptibility of the elements can at present only be regarded as a periodic function of the atomic weight, and cannot be brought into relation with the atomic volume [see Abstract No. 1314 (1900)], the author maintains that the relation established by himself is not only without irregularities, except in the case of carbon, but brings the susceptibility into connection with the melting-point, the hardness, and other properties depending upon the aggregation of the atoms in space. The strongly magnetic elements find their places in the minima of the curve of atomic volume, and in the portions preceding the minima. The diamagnetic substances are found grouped

about the maxima, the extremes being somewhat displaced towards the lesser atomic weights. The secondary minima are associated with feebly diamagnetic or even paramagnetic bodies. Carbon and zirconium are diamagnetic, although they stand in the even series of Mendelejeff's table, and the diamagnetic character of Li, Na, K, Rb, Cs, Ca, Sr, and Ba renders it impossible to regard the atomic susceptibility as a periodic function of the atomic weight. E. E. F.

138. *Change of Magnetic Moment by Shocks.* **K. Krüse.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 195–218, Jan.–March, 1900.)—The bar magnets of Klemenčič [Abstract No. 1867 (1900)] are subjected to violent treatment, and the resulting change of magnetic moment measured. The shocks are produced in three ways: first, by letting the magnets fall down vertical brass tubes, of different heights, on to a marble slab; second, by moving the magnets up to make contact with a soft iron bar, then tearing the magnet off; third, by placing the magnet on the centre of a soft iron plate and then drawing it off lengthwise. Fifteen tables of the results of these treatments are given. Among other things, it is found, in bumping the magnets, that the greatest decrease is after the first fall, and that only in isolated cases does the moment remain unchanged after frequent falls from the same height. The total decrease of moment varies between 1·6 per cent. and 25·6 per cent. The changes due to pulling the magnets from contact with a soft iron bar are very slight, being an increase after the first separation, changing to a decrease after ten separations. Drawing a magnet off a soft iron plate sometimes diminishes its moment 28 per cent. G. E. A.

139. *Constancy of Permanent Magnets.* **I. Klemenčič.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 242–275, April, 1900.)—Observations extending over a year were made with steel bars obtained from makers in Vienna, Zurich, Hagen, Berlin, and Paris, but chiefly with forty magnets of Wolfram steel of five different kinds made by Böhler. The bars were magnetised in a homogeneous field of 600–700 c.g.s. and were, after magnetisation, put into boxes in the E—W position. Comparisons were made by measuring the deflections of a magnetometer needle due to the various magnets, to a constant current in a manganin coil, and to two "normal" magnets magnetised in 1896. Tables appended show that: (*i*) The decrease of magnetic moment with time varies in the reverse direction with the dimension ratio [Abstract No. 1867 (1900)]; (*ii*) In the first days after magnetisation the thin magnets hold their magnetism best.

A classification of the magnets according to their quality, made after fifteen months' observations, is quite different to one made three weeks after magnetisation; and further, the former classification is almost the opposite of one made by Krüse (see preceding Abstract) for the same magnets; *e.g.*, those which, under undisturbed conditions, come in the order 1, 2, 3, 4, 5, (Klemenčič), are, in order of ability to withstand shocks, 5, 3, 4, 1, 2 (Krüse). Magnets with small coercive forces give the best results in undisturbed conditions. G. E. A.

140. *Magnetic Moment of Magnets and Temperature.* **M. Prodinger.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 383–399, May, 1900.)—The temperature coefficient of the magnetic moment of magnets is here experimentally investigated and is found to vary with the linear dimensions, with the magnetic moment, and with the specific electrical resistance.

The results lead to the following conclusions: The specific resistance, which has a considerable influence on the magnitude of the temperature coefficient, appears to have no influence on the relationship between the temperature coefficient and the magnetic moment. Two conditions seem to control the relationship between the temperature coefficient and the magnetic moment; these are the ratio of length to thickness and the thickness. In magnets whose length is great compared with the thickness (23 to 27 times), and whose thickness is small (4 mm. to 7·3 mm.), the temperature coefficient increases considerably with the magnetic moment. In magnets of about the same thickness as above (5·37 to 6·95 mm.), but whose length is less (10·03 to 10·79 times the thickness), the increase in temperature coefficient due to increase in magnetic moment is much less. In magnets with a small ratio of length to thickness (10·14 and 6·52) and of considerable thickness (9·86 to 9·20), the temperature coefficient no longer varies with the magnetic moment but is constant. J. B. H.

141. *Magnetisation of Iron Filings mixed with Ferro-Manganese.* **E. Wilson.** (Electrician, 45. pp. 894–896, Oct. 5, 1900.)—The filings, mixed with 17 per cent. by weight of ferro-manganese powder, containing 85 per cent. manganese, were placed in a hollow cylinder of asbestos, wound with exciting and exploring coils. From experiments it was found that the ferro-manganese diminishes the hysteresis of the filings, after heating to about 900° C., and the increase in permeability, observed after heating simple filings to that temperature, is greatly reduced. W. H. E.

142. *Bar Magnets.* **C. Chistoni.** (N. Cimento, 12. p. 37, July, 1900. From Mem. R. Accademia di Modena, serie 3, vol. 3.)—Solid steel bars have a higher permeability than hollow bars, probably owing to the fact that the former have only one tempered surface, while the latter have two. Bars which present thermal anomalies also present anomalies with respect to permeability. E. E. F.

143. *Permanent Magnets.* **C. Chistoni** and **G. G. de Vecchi.** (N. Cimento, 12. pp. 39–42, July, 1900. Mem. R. Accad. di Modena, serie 3, vol. 2, pp. 125–272.)—In this part of their work the authors examine the behaviour of steel magnets containing tungsten, and of other magnets when subjected to various tempering, hardening, and annealing processes. They do not arrive at a definite judgment concerning Barus' and Strouhal's process of magnetisation. E. E. F.

144. *Magnetic Effect of Electric Convection.* **V. Crémieu.** (Comptes Rendus, 131. pp. 797–800, Nov. 12, 1900.)—To confirm his previous negative result [see Abstract No. 1666 (1900)], the author has repeated the experiments of Rowland and Himstedt, who claimed to have shown the generation of a magnetic field by a moving electric charge. An ebonite disc, covered over with gilt sectors, was mounted inside a hollow wheel. The interior of the wheel was lined on both sides of the ebonite with brass, covered with sheets of mica, on which were stuck sectors of tinfoil. An astatic magnetic needle was used for detecting any magnetic field created by the revolution of the ebonite disc when the disc and the brass lining were given opposite charges. No deflection was observed, and thus Rowland and Himstedt's positive result is directly contradicted. But there is an important difference of detail in the

arrangement, for the latter stuck the tin-foil sectors on glass and had no brass lining. When the latter is removed a deflection is actually obtained, but it remains far inferior to what should be expected if the charges on the moving sectors were equivalent to a current. The author attributes it to small impulsive currents which are produced in the tin-foil sectors as the gilt sectors pass them. These impulsive currents are absorbed when the brass lining is introduced, or rather they induce opposite currents in the latter which neutralise the effect upon the astatic needle. E. E. F.

145. *Influence of Magnetisation upon Torsion.* **K. Schreber.** (Phys. Zeitschr. 2. pp. 18–20, Oct. 13, 1900.)—From the ample material supplied by Grösser (Rostock, 1894) the author has unravelled the following relations between magnetisation and torsion: Every iron or steel wire free from torsion acquires a permanent twist under magnetisation, which, with increasing field intensity, tends towards a maximum. The direction of the torsion is, strange to say, independent of the direction of magnetisation. In fact, it is reversed several times in the same wire as the field increases in strength. In iron the previous history of the wire does not seem to affect the amount of the twist, but in steel it does, to an extent which cannot as yet be stated in a simple manner. Moreover, the permanent twist is greater in steel than in iron. Besides the permanent twist, the wire experiences a temporary twist, which increases with the field as soon as the permanent twist has attained its maximum. Beyond that maximum, also, the temporary twist has always the same sign. An eye looking along the lines of force would always see the twist taking place in the direction of the hands of a watch. This practically diminishes the torsional elasticity in that direction. E. E. F.

146. *Trend of the Horizontal Component of the Earth's Magnetic Field in France.* **E. Mathias.** (Comptes Rendus, 131. pp. 554–556, Sept. 24, 1900.)—The author has made a magnetic survey of the neighbourhood of Toulouse, and finds that if ΔH is the difference between the value of the horizontal component at a given station and that at Toulouse, while Δ long. and Δ lat. are respectively the differences between the longitude and latitude of the station and Toulouse, then $\Delta H = -1{\cdot}26\ (\Delta\ \text{long.}) - 7{\cdot}42\ (\Delta\ \text{lat.})$. This expression seems to hold also for the rest of France, as shown by the observations of Moureaux. W. W.

REFERENCES.

147. *Models for the Electric Discharge in Gases.* **A. Garbasso.** (Phys. Zeitschr. 2. pp. 49–52, Oct. 27, 1900.)—A description of two models designed to illustrate the mechanism of the phenomena of electric discharge in gases investigated by Hertz, E. Wiedemann and H. Erbert, A. Sella and Q. Maiorana. E. H. B.

148. *Simple Relay for Experiments with Electric Waves.* **W. B. v. Czudnochowski.** (Phys. Zeitschr. 2. pp. 3–4, Oct. 6, 1900. Also Zeitschr. f. d. physikalischen u. chemischen Unterricht, xiii., Heft. 5.)

149. *Resistance of Bismuth in a Magnetic Field.* **W. Eichhorn.** (Ann. d. Physik, 3. 1. pp. 20–42, Sept., 1900.)—Paper similar to Abstract No. 1301 (1900).

150. *Magnets for Magneto-Optics.* **M. T. Edelmann.** (Elektrotechn. Zeitschr. 21. p. 794, Sept. 20, 1900.)—A description of a few convenient forms of electromagnets for research in magnetism and electro-optics. R. A.

151. *Standard Cells.* **J. Henderson.** (Elect. Engin. 26. pp. 121–124, July 27, and 155–158, Aug. 3, 1900.)—A general description of standard cells, and a *résumé* of recent research. W. R. C.

152. *Solution of Problems Involving Mutual Inductance by Vector Methods.* **J. Herzog** and **C. P. Feldmann.** (Elektrotechn. Zeitschr. 21. pp. 307–309, April 19, 1900.)—The authors use the well-known method in which a resistance and a reactance are represented by two mutually perpendicular vectors, and apply it to the solution of various problems involving mutual as well as self-inductance. A. H.

153. *Graphical Methods Applied to Problems in Polyphase Distribution.* **F. Blanc.** (Elektrotechn. Zeitschr. 21. pp. 733–735, Aug. 30, and 749–752, Sept. 6, 1900.)—The following is the problem considered by the author: Given three conductors maintained at given alternating p.d.'s, and having three inductive loads, of known impedance and power-factor, connected to them star-fashion, to find the currents taken by the star-connected circuits and the p.d.'s between the neutral point and each of the three-line wires. The author solves this problem by a graphical method, and illustrates the solution by working out a number of numerical examples. A. H.

154. *Skin Effect in Iron Wires.* **B. Hopps.** (Electrician, 45. p. 920, Oct. 12, 1900.)—The author gives tables and curves containing the results of some experiments on the impedance of iron rods (varying from 0·105 inches to 0·975 inches in diameter) to alternating currents. No attempt is made to separate the true resistance component of the impedance from the reactance component. A. H.

155. *Contact Methods of Determining Wave-Shapes.* **F. Niethammer.** (Elektrotechn. Zeitschr. 21. p. 309, April 19, 1900.)—A brief discussion of the various sources of error which may arise in connection with the different arrangements which may be used for determining wave-shapes by means of "contact" or "point" methods. A. H.

156. *Laboratory Instruments in the German Section of the Paris Exhibition.* **H. Armagnat.** (Écl. Électr. 24. pp. 321–334, Sept. 1, 1900.)—A very full description of some new electrical testing instruments, galvanometers, electro-dynamometers, resistances, potentiometers, ammeters for large currents, &c., exhibited by the principal German firms. E. K. S.

157. *Magnetic Elements at Falmouth.* **E. Kitto.** (Roy. Soc., Proc. 67. pp. 139–158, Oct. 26, 1900.)—The mean hourly readings of the declination and horizontal force magnetographs for five "quiet" days in each month of the years 1897, 1898, and 1899 are given; also the hourly means of the vertical force for 1898. W. W.

158. *Measuring Instrument for Electrochemical Lecture Experiments.* **W. L. Miller** and **F. B. Kenrick.** (Journ. Phys. Chem. 4. pp. 599–618, Oct., 1900.)—A measuring instrument is described, which is provided with a dial 2 feet in diameter is dead-beat, reads directly ohms, megohms, volts, and amperes, their multiples and submultiples, and can be changed from any one of these uses to any other without delay. Fifteen examples are given for the use of the instrument for quantitative lecture experiments in electro-chemistry. T. M. L

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

159. *Action of Bromine on Phenylsulpho-acetic and α-Phenylsulphopropionic Acids.* **L. Ramberg.** (Zeitschr. Phys. Chem. 34. pp. 561-592, Sept. 7, 1900.)—The reaction between bromine and phenylsulpho-acetic acid in aqueous solution takes place in several phases, the first two, the products of which are mono- and dibromophenylsulpho-acetic acids respectively, having velocities approximately in the ratio 1·6 : 1. With α-phenylsulphopropionic acid, however, the action of bromine is one of simple substitution. In both cases, if the dilution is great, the velocity of the reaction is very nearly proportional to the product of the concentrations of the bromine and acid, whilst with more concentrated solutions it varies approximately as the product of the concentration of the acid and the square root of that of the bromine. The relative velocity increases with the dilution. T. H. P.

160. *Composition of the Surface-Layers of Aqueous Solutions.* **J. v. Zawidzki.** (Zeitschr. Phys. Chem. 35. pp. 77–80, Oct. 5, 1900.)—In order to study the distribution of a dissolved substance in the interior and in the surface-layers of a solution, aqueous hydrochloric and acetic acids were each mixed with such proportions of saponin as yielded solutions which on shaking formed a permanent froth. A current of air bubbles was passed through these liquids, the froth thus formed being condensed. The relative concentrations of the acid in the original liquid and in the condensed froth are found to be 33·50 and 33·61 for the acetic acid, and 20·03 and 20·19 in the case of hydrochloric acid. This change in concentration of the froth is due partially, but not entirely, to evaporation, which would, however, influence the results in opposite senses for the two acids employed. The author further finds that if air is passed through a saponin solution, and the foam removed as it is formed, after a certain time foam production ceases, whilst the liquid obtained by condensing the foam possesses in increased measure the capacity of forming foam. If alcohol be gradually added to an aqueous saponin solution, a point is reached when the liquid refuses to yield froth when shaken, while the subsequent addition of a few drops of water restores the frothing. Solutions of isobutyric acid do not give foam even when considerable proportions of saponin are present, but on neutralising the acid with a base the liquid readily froths. T. H. P.

161. *Action of Heat on the Absorption Spectra and Chemical Constitution of Saline Solutions.* **W. N. Hartley.** (Roy. Dublin Soc., Trans. 7. pp. 253–312, Sept., 1900.)—Descriptions and measurements are given of the absorption spectra of various metallic salts, and the changes produced in these when the temperature is raised are also described. The principal salts investigated were those of nickel, copper, cobalt, chromium, uranium, and didymium, and also potassium permanganate. The following are the conclusions reached by the author as to the molecular constitution and dissociation phenomena of saline solutions : (1) When a definite crystalline hydrate dissolves in a solvent which is not water, and is without chemical action upon it, the molecule of the salt remains unchanged in chemical composition. (2) In any series of salts which are anhydrous, and which do not form well-defined crystalline hydrates, the action of heat up to the temperature of 100° C. does not cause any further alteration in their absorption spectra, beyond that which is usual with substances which undergo no chemical change by such rise of temperature. The change is usually an increase in the intensity of the absorption, or a slight widening of the absorption bands. (3) As a rule crystalline metallic salts in which water is an integral part of the molecule, dissolve in water at ordinary temperatures, without dissociation of the molecule. (4) Crystallised hydrated salts dissolved in a minimum of water at 20° C. undergo dissociation by rise of temperature. The extent of the dissociation may proceed as far as complete dehydration of the compound, so that more or less of the anhydrous salt may be formed in the solution. (5) The most stable compound which can exist in a saturated solution at 16° or 20° is not always of the same composition as the molecule of the crystallised solid at the same temperature, since the solid may undergo partial dissociation from its water of crystallisation when the molecule enters into solution. (6) Saturated solutions of deliquescent salts combine with water when diluted to constitute molecules of more complex hydrated compounds in such solution. (7) When a saturated solution of a coloured salt undergoes a great change of colour upon dilution, or any remarkable change in its absorption spectrum due to the same cause, the dilution is always accompanied by a considerable evolution of heat. J. J. S.

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examined after four years of such contact. Successive slices were cut at right angles to the axes of the cylinders, the first being about 0·75 mm. thick, and each of those succeeding it about 2·8 mm. thick. Assays of these slices showed that those in contact with the gold had absorbed a quantity equivalent to about 1 oz. 6 dwt. of gold per ton of lead, whilst the next layers contained less, the next still less, and so on, the amount even in the poorest layer being in the proportion of 1¼ dwt. per ton. The results shown by different experiments were not identical (probably because of the difficulty in ensuring perfect contact between the gold and the lead surfaces) but were all of the same order. The importance of temperature in relation to diffusion is shown by the fact that the amount of gold that would diffuse in solid lead at the ordinary temperatures in 1,000 years is the same as that which would diffuse in molten lead in a single day. Preliminary experiments, in which a current of 1·5 amperes was passed continuously through the clamped joint for 544 hours at 150°, seem to show that a solution of gold in lead does act to a small extent as an electrolyte. The failure of the author, in 1887, to obtain indications of electrolysis in a solution of gold in molten lead by the passage of a current of 300 amperes may have been due to the distribution of the precious metal by diffusion through the mass at the high temperature of the experiment. W. G. M.

165. *Action of Copper-Zinc Alloys on Nitric Acid.* **J. H. Gladstone.** (Phil. Mag. 50. pp. 231–237, Aug., 1900. Paper read before the Physical Society, May 11, 1900.)—The author shows by experiments that the alloys give much more nitrous acid and very much less ammonia than the corresponding mixtures. These results affect seriously the experiments made by Galt and by Baker to determine the heat of formation of copper-zinc alloys, in which it was assumed that the end state was the same whether one started with the alloy or the mixture. F. G. D.

166. *Alloys of the Gold-Copper Series.* **W. Roberts-Austen** and **T. K. Rose.** (Roy. Soc., Proc. 67. pp. 105–112, Oct. 26, 1900.)—The eutectic alloy of gold and copper appears to be that containing 18 per cent. of the latter metal, the melting-point of the alloy being about 905° C. (the fusing-points of pure gold and pure copper being respectively 1,063° C. and 1,083° C.). This proportion is equivalent to 60 atoms of gold to 40 atoms of copper, and is therefore the same as the atomic proportion of the silver-copper eutectic. Unlike most other eutectics (but like that of copper-silver) the gold-copper eutectic is brittle, breaking under a load of 7·87 tons per square inch with an elongation of only 3·8 per cent. In the limited mutual solubility of the two metals, and in the liquation which attends solidification, the gold-copper and silver-copper series of alloys also resemble each other closely. Copper appears, however, to be more soluble in gold than in silver, so that the characteristics of the gold-copper alloys are less marked, and consequently less easy to detect. Liquation, which is so marked in the case of standard silver (in which the precious metal tends to segregate to the centre) is observable, but to a much less extent in standard gold, in which case, however, the outside is usually found to be richer in gold than the inside. W. G. M.

167. *Passive State of Metals.* **W. Hittorf.** (Zeitschr. Elektrochem. 7. pp. 168–170. Discussion, pp. 170–171, Oct. 11, 1900. Paper read before the Deutsche Elektrochem. Gesell. Zurich.)—The close resemblance between the passive state of iron and of chromium shows that the former can scarcely be

due to a film of oxide protecting the metal. When chromium assumes the passive state it dissolves as chromic acid if the anion contains oxygen or can attack the water and liberate oxygen. Iron does not dissolve under these conditions, since ferric acid is unstable, but bubbles of oxygen are liberated and the iron behaves as a noble metal; **Strasser**, however, points out in the discussion, that when a fused alkali is used as electrolyte the iron dissolves, probably as potassium ferrate. The passive state of iron is rendered more stable by contact with an electronegative metal or a peroxide, but is instantly destroyed by contact with an electropositive metal like zinc, which converts it into a kathode. [See also Abstract No. 2283 (1900).] T. M. L.

168. *Hydrolysis of Ferric Chloride.* **H. M. Goodwin** and **F. W. Grover.** (Phys. Rev. 11. pp. 193–214, Oct., 1900.)—This paper is a continuation of a former one by Goodwin (Phys. Rev. 9. p. 251, 1896) and describes experiments on the influence exerted by change of temperature, by a magnetic field and by the presence of colloidal ferric hydroxide on the hydrolysis of ferric chloride; as in the previous work, the extent of hydrolysis is determined by measuring the electrical conductivity of the solution. It is found that a depression of temperature is accompanied by a diminution in the velocity of the reaction, by an increase of the initial lag, that is, of the period elapsing before hydrolysis begins, and also by an increase in the time required for a state of equilibrium to be attained. Lowering the temperature further tends to greatly diminish the separation of the oxychloride from solutions of ferric chloride. The addition of colloidal ferric hydroxide to the chloride solutions causes the hydrolytic action to be accelerated to an extent approximately proportional to the amount of the added hydroxide; this confirms the view that the hydrolysis occurring in ferric chloride solutions is due to the gradual formation of colloidal hydroxide from the ionised chloride. The reaction seems to be unaffected by a magnetic field. T. H. P.

169. *Gaseous Solutions Physically and Chemically Supersaturated.* **Berthelot.** (Comptes Rendus, 131. pp. 637–646, Oct. 22, 1900.)—On carefully mixing hydrogen peroxide and potassium permanganate in suitably dilute solutions and in presence of an excess of sulphuric acid no evolution of oxygen takes place; gas is, however, given off on agitating the liquid or on adding some powdered material such as spongy platinum. The author describes experiments carried out to determine whether such solutions are merely supersaturated with respect to the oxygen or whether an unstable highly oxygenated compound is present. From a comparison of the changes of temperature of the mixture before and after evolution of oxygen with those of a similar liquid from which the gas has already been removed by shaking, the author arrives at the conclusion that the oxygen is present in the form of an unstable compound other than hydrogen peroxide, and that heat is developed by the decomposition of this compound. T. H. P.

170. *Crystallography of the Double Selenates, $R_2Zn(SeO_4)_2.6H_2O$.* **A. E. Tutton.** (Roy. Soc., Proc. 66. pp. 248–250, April 14, 1900, and 67. pp. 58–84, Oct. 8, 1900.)—This paper contains results of a detailed comparative study of the morphological and physical properties of the mono-symmetric crystals of the double selenates of the composition $R_2Zn(SeO_4)_2.6H_2O$, where R represents K, Rb or Cs. It is found in all cases that the morphological properties and also the whole of the specific and molecular optical constants of rubidium-zinc selenates occupy an intermediate position between those of the potassium and cæsium zinc salts. Comparison with the results formerly obtained for the analogous double zinc sulphates shows that replacement of sulphur by selenium is generally accompanied by a change in the morphological and physical constants similar to that produced by the replacement of one alkali metal by another of higher atomic weight. T. H. P.

171. *Vapour Pressures of Fluid Mixtures.* **J. v. Zawidzki.** (Zeitschr. Phys. Chem. 35. pp. 129–203, Oct. 16, 1900.)—The author describes a series of experiments undertaken primarily in order to verify the relation determined by Margules between the partial pressures of its two constituents and the composition of a fluid mixture. A modified form of Lehfeldt's apparatus was employed, the vessel in which the mixture was boiled being of about 200 c.c. capacity, and being boiled on a thermostat maintained at a temperature 1° above the boiling-point of the mixture. Steady ebullition was ensured by passing an electric current through a pair of thick copper wires dipping in the liquid and connected at their extremities by a small piece of thin platinum wire; previous experiments proved that this caused no chemical change in the liquid. The vapours given off by the boiling liquid were condensed in a vessel surrounded by melting ice; connections with the condenser were so made that, when a sufficient quantity of the distillate was collected, it could be removed without disturbing the rest of the apparatus. The condenser and boiler were in communication, by means of a tube furnished with a stopcock, with a vessel in which the pressure could be regulated and measured.

A series of experiments was conducted as follows: One liquid was placed in the boiler and its vapour pressure determined at the required temperature; a small quantity of the second liquid was added and the first distillation carried out at the same temperature, the vapour pressure being noted; at the end of this distillation a specimen, about 1 c.c. of the mixture, was withdrawn by a pipette, and with the distillate was set aside for analysis; a fresh portion of the second fluid was added, and a second distillation made. After the requisite number of distillations the boiler was emptied and dried by a current of air. Several series of experiments could be carried out without taking the apparatus to pieces.

The coefficients of refraction of the distillates and the fluid mixtures were measured and their constitution thence determined by an analytical-graphical method. The coefficients were measured for a series of mixtures of the two liquids; the differences between the molecular-percentage constitution of each mixture, as known, and as deduced from the refraction coefficient by the linear relation, were represented graphically; this curve gave the correction to be applied to the constitution of any mixture of the liquids as calculated by means of the linear relation.

Various sources of error are pointed out and estimates formed of the maximum and average errors thence arising. Tables are given for the sixteen series of mixtures examined showing the coefficients of refraction of various mixtures, the coefficients of refraction and the thence deduced molecular-percentage composition of the fluid and the distillate, the total vapour pressure and the partial vapour pressures of the constituents as calculated from the composition of the distillate.

The relation deduced by Margules between the partial pressure (p_1, p_2) and the molecular fractional composition (x) of the fluid mixture was—

$$\frac{d \log p_1}{d \log x} = \frac{d \log p_2}{d \log (1-x)}.$$

Other methods of verification being uncertain, the author preferred to verify the integrated form, assuming a general form of functional relation between p_1, p_2 and x, and determining relations between the constants by the above equation. Three ways of determining the constants, and thence the partial pressures, present themselves, viz.: (1) From one of the observed partial pressure curves; (2) from the tangents to the total pressure curves at the points $x=0$, $x=1$; (3) by gradual adaptation to the observed values of the pressures. The results arrived at by these methods are compared. The simplest case is when the constants vanish, which occurs when the concentration ratio in the vapour phase is to that in the fluid phase in a constant ratio equal to the ratio of the vapour pressures of the pure fluids; two examples of this are given and the relation verified within the estimated limits of experimental error. The relation is also verified for seven pairs of mixtures of fluids with normal vapour densities, the results of the experiments and calculations being tabulated and exhibited graphically. For mixtures of fluids with abnormal vapour densities, singled and doubled molecules occurring in the vapour of one fluid, similar relations are theoretically proved, and experimentally verified for mixtures of acetic acid with benzine and toluene, the molecular fractional composition being deduced from the simple, from the double, and from the mean molecular weight. The relation is also tested for mixtures of pyridine and acetic acid and pyridine and water, when feeble chemical combinations occur. The validity of the relation is found unaffected in the first case, but no certain conclusions can be drawn in the second case. W. E. T.

172. *Modern Theory of Solutions.* **E. F. Morris.** (Manchester Lit. & Phil. Soc., Mem. 44. 16. pp. 1–4, 1899–1900.)—The author's views can be best explained by two quotations:—

"An osmotic membrane seems to be only a method for keeping two otherwise completely miscible liquids in contact, in such a manner that their surface-tension effects can be observed."

"The use of the term *dissociation* is most misleading, since it is impossible to separate finite quantities of the ionised bodies without the application of energy." F. G. D.

173. *Heat of Solution and Solubility in the Case of Electrolytes.* **J. J. van Laar.** (Zeitschr. Phys. Chem. 35. pp. 11–17, Oct. 5. 1900.)—In this paper the author gives a short summary of the differences between his formula and that deduced by van't Hoff. His conclusion is that the two formulæ differ only in respect of a term which *in practice* is quite negligible, so that the differences actually observed in various cases do not arise from the formulæ themselves (which are differential formulæ), but are due to errors occurring in the practical application of the *integrated* equations. [See further Abstract No. 1544 (1899).] F. G. D

174. *Solubility of the Alkaline Earth Carbonates in Solutions of Carbonic Acid.* **G. Bodländer.** (Zeitschr. Phys. Chem. 35. pp. 23–32, Oct. 5, 1900.) —From the solubility of carbonic acid in water, the conductivity of the solution, the dissociation of water and the solubility of the carbonate in pure water, the author calculates the solubility of the alkaline earth carbonates in solutions of carbon dioxide corresponding to different pressures of the gas, the results being in good agreement with the experimental values. The concentration of the HCO_3 ions (in gramme-ions per litre) in a solution of calcium carbonate at 16° is given by the expression $0{\cdot}018\sqrt[3]{P}$, where P is the

pressure in atmospheres of the carbon dioxide; for barium carbonate at 16° by $0{\cdot}0158\sqrt[3]{P}$, and for magnesium carbonate at 12° by $0{\cdot}89\sqrt[3]{P}$. The extent of hydrolysis of the carbonates in pure water is calculated in two ways, the percentage hydrolysed being for calcium carbonate 80 or 88·4, and for barium carbonate 78·4 or 84·2. In the case of magnesium carbonate the hydrolysis cannot be accurately calculated, as it goes further than is represented by the equation $CO_3 + H_2O = HCO_3 + OH$, and results in the formation of free carbon dioxide and basic carbonate. Calculations are also given of the hydrolysis of the alkali bicarbonates, which are only stable in presence of a certain proportion of free carbonic acid. For a solution saturated at atmospheric pressure with carbon dioxide and sodium bicarbonate, 0·04 per cent. of the latter is decomposed into sodium carbonate and carbon dioxide. If, however, the pressure of the carbon dioxide be equal to that which it has in the air, namely, 0·0004 atmospheres, the proportion of carbonate formed is much greater, and so therefore is the apparent solubility of the bicarbonate, which can only be regarded as having a definite value for a definite pressure of carbon dioxide. T. H. P.

175. *Equilibria between Cuprous and Cupric Ions.* **G. Bodländer.** (Zeitschr. Elektrochem. 7. pp. 159–160, Oct. 4, 1900. Paper read before the 72nd Versammlung deutscher Naturforscher u. Aerzte in Aachen, Sept. 22, 1900.) —The author's first object was to ascertain whether the p.d. between metallic copper and a normal solution of cuprous ions was the same as that between copper and a normal solution of cupric ions. It was found that when air was quite excluded cuprous chloride is partially decomposed as follows: $2CuCl = Cu + CuCl_2$, or $2\overset{+}{Cu} = Cu + \overset{++}{Cu}$ (there was also a slight hydrolysis). A state of equilibrium results, the respective concentrations (for the saturated solution) being, for $\overset{+}{Cu}$, 0·0004 — normal, and for $\overset{++}{Cu}$, 0·0028 — normal. Since these ions are in electrical equilibrium with the copper, and the p.d.'s for solutions containing cupric ions alone are known, the problem can be solved. The calculated values for normal solutions are :—

$$-0{\cdot}43 \text{ volt } (Cu - \overset{+}{Cu})$$

$$-0{\cdot}34 \text{ volt } (Cu - \overset{++}{Cu}),$$

taking the p.d. of the normal hydrogen electrode (normal concentration of hydrogen ions) as zero.

An investigation of the equilibrium between cuprous and cupric ions showed that the ratio C_0^2/C_1 was constant. From this it follows that the cuprous ions do not possess the structure $\overset{+}{Cu} - \overset{+}{Cu}$, but are, in fact, monatomic.

For other very interesting applications of the foregoing results to the facts of inorganic chemistry reference must be made to the original paper.

F. G. D.

176. *Pressures of Ammonia in Equilibrium with Metal-Ammonium Solutions.* **W. Gaus.** (Zeitschr. Elektrochem. 7. pp. 158–159, Oct. 4, 1900. Paper read before the 72nd Versammlung deutscher Naturforscher u. Aerzte in Aachen, Sept. 22, 1900.)—The partial pressure of the ammonia was ascertained by passing a measured quantity of electrolytic gas through the solution to be examined and then into standardised hydrochloric acid solution. The exact

point of saturation was determined by the break in the conductivity curve for the latter solution. Some salts *increase* the pressure of the ammonia, while others *lower* it. The former is due to the general effect produced on the solvent medium by the electrolyte ; the latter to the formation of complex metal-ammonium kations. The author discusses his results from the point of view of the Abegg-Bodländer theory of electro-affinity. F. G. D.

177. *Electromotive Activity of the Elementary Gases.* **E. Bose.** (Zeitschr. Phys. Chem. 34. pp. 701–760, Sept. 18, 1900. Published in abstract as "Habilitationsschrift" of the University of Breslau.)—This is a study of gas-batteries with special consideration of Grove's, and the author's conclusions may be thus summed up : (1) The electromotive activity of the elementary gases is conditioned by their solubility in the metals forming the electrodes. (2) The gases dissolved in the metal are to be considered as dissociated either wholly or partially into single atoms by reason of the high dissociating power of metals. (3) The ions of an electromotively active substance are to be looked on as formed in the electrode. (4) The electrolytic solution-pressure is measurable by the product of the osmotic pressure of these pre-formed ions by a factor, constant for each solvent, which may most simply be termed the electrolytic coefficient of distribution. (5) The general theory of gas batteries in which formation of the solvent occurs may be developed on this view. (6) The saturation of the electrodes with the gases is a process of diffusion in the metal of the electrodes which proceeds with extraordinary slowness. (7) The Grove gas battery works reversibly, but its e.m.f. with the gases under atmospheric pressure is in any case higher than the received value. (8) The acid and alkaline H-O batteries differ in the place of formation of water, this being at the O-electrode in the acid element and at the H-electrode in the alkaline. (9) The second decomposition-point corresponds to an irreversible process. R. E. B.

178. *Calomel Electrode.* **Rotté.** (Journ. de Physique, 9. pp. 543–545, Oct., 1900.)—Employing the capillary electrometer and the Lippmann method, the author has satisfied himself that the e.m.f. of the normal calomel electrode is 0·56 volt. F. G. D.

179. *Action of Light on Lead Peroxide.* **F. Peters.** (Centralblatt f. Accumulatoren u. Elementenk. 1. p. 279, Aug. 15, 1900.)—M. U. Schoop has stated that the lead peroxide layer produced on lead is decomposed by the action of light. This statement the author doubts, and cites some of his own experiments. Two lead plates were covered electrochemically with an oxide layer, and after thorough washing and being dried in the dark, one was submitted to the light for 19–23 days, and received 35–40 hours of direct sunlight ; the other was kept in the dark. As Schoop observed, the colour of the one exposed to light became less intense ; but a chemical estimation of the amount of PbO_2 failed to confirm that decomposition had resulted. He concludes that the colour change is due to some physical or molecular effect. W. W. H. G.

180. *Action of Water on Pure Indiarubber.* **H. L. Terry.** (Electrician, 45. pp. 916–917, Oct. 12, 1900.)—Hancock sealed a bag of pure rubber containing rather more than 12 oz. of water, and weighed it at intervals with the following results :—

Date	Oct., 1826.	Oct., 1827.	Oct., 1835.	Nov., 1844.	Oct., 1849.	Feb. 1851.	May, 1854.
Weight	17 oz. 4 dr.	17 oz. 2 dr.	16 oz. 0 dr.	14 oz. 12 dr.	13 oz. 4 dr.	7 oz. 8 dr.	3 oz. 14 dr.

Their loss of weight occurred at atmospheric pressures. Obach gives 24 per cent. as the absorption of water by pure rubber in four months. Increasing the pressure to 8 atmospheres resulted in rubber absorbing in five minutes as much water as it otherwise takes up in two hours. M. O'G.

181. *Metastability of the Cadmium Standard Cell.* **E. Cohen.** (Zeitschr. Phys. Chem. 34. pp. 621–631, Sept. 7, 1900. *Cf.* Abstract No. 2065 (1900).)—The fact that cadmium sulphate exists in two modifications was pointed out some years ago, and solubility determinations showed that the transition-point was at 15°, so that below this temperature the sulphate can exist in either the stable or the metastable modification. It is now shown that the cadmium amalgam is metastable below 23°, and is liable to pass spontaneously into a stable modification, causing a rise in e.m.f., of 0·005 volt at 0° C. The cells usually supplied are in the metastable condition, and are therefore of no use as standards of e.m.f. below 23°, since an abrupt increase of e.m.f. may occur at any time, and would not usually be noticed. T. M. L.

182. *Thermodynamics of Standard Cells.* **E. Cohen.** (Zeitschr. Phys. Chem. 34. pp. 612–620, Sept. 7, 1900.)—The e.m.f. of the combination—$Cd \mid CdSO_4$ (dil. sol.) $\mid CdHg$ (14·3 per cent. Cd)—was found to be 0·05577 volt at 0° and 0·04993 at 25°, whence $E = 0{\cdot}0515$ volt at 18°, and $\frac{dE}{dT} = -0{\cdot}000233$. Hence by using Helmholtz's equation the heat required to separate one gramme atom of cadmium from a 14·3 per cent. amalgam is calculated to be 5,436 cal. The solution of this quantity of cadmium at 18° causes the separation from the saturated solution ($CdSO_4 + 15{\cdot}17\ H_2O$) of 1·212 mols. of the salt, $CdSO_4 + \frac{8}{3}H_2O$, so that the thermal changes resulting from the hydration of the cadmium sulphate amount to 7,822 cal. The total thermal change in the element per atom of cadmium dissolved is therefore $-5436 + 7822 + (219900 - 175000)$ cal. $= +47880$ cal., a number which is in satisfactory agreement with the value $+47286$ cal., deduced from the e.m.f. of the cell. T. M. L.

183. *Dissociation-Equilibrium in Highly Dissociated Electrolytes.* **H. Jahn.** (Zeitschr. Phys. Chem. 35. pp. 1–10, Oct. 5, 1900.)—The author considers possible objections to his previous work [Zeit. Phys. Chem. 33. 545, 1900; Abstract No. 1888 (1900)]. He shows first that the differential equation of Nernst can be deduced without assuming any laws for the osmotic pressure of the solution, and can be expressed directly in terms of the concentrations.

He also shows how any assumption as to the completeness or incompleteness of the dissociation in the N/600 solutions can be entirely dispensed with, and recalculates his results on this basis. Ostwald's dilution law for highly dissociated electrolytes receives thereby a further very striking confirmation. F. G. D.

184. *Model of Ionic Motions.* **F. Kohlrausch.** (Zeitschr. Phys. Chem. 34. pp. 559–560, Sept. 7, 1900.)—The author describes a model illustrating electrolysis, which is in some respects superior to that devised by Müller [see Abstract No. 1895 (1900)]. It consists of an upright board having a number of parallel channels in which small weights are suspended by threads wound on pulleys of various diameters, which impart to them velocities in proportion to the velocities of the ions they represent. A special pulley is provided for the ions H and OH, whose velocity is exceptional. Two ions having approximately the same velocity may be attached to the same pulley. E. E. F.

185. *Accessory Reactions in Electrolysis.* **A. Brochet.** (Comptes Rendus, 131. pp. 616–618, Oct. 15, 1900.)—When concentrated solutions of sodium hypochlorite are electrolysed, more of this salt is decomposed, and more sodium chlorate is formed, than theory predicts. This result is shown to be due to an *accessory* reaction which is independent of the electrolytic action, although indirectly caused by the latter. The solution in the immediate neighbourhood of the anode is always acid, the consequence of which is that, beside the hypochlorous acid converted electrolytically into chloric acid, a further portion undergoes the same transformation by the purely chemical process of anto-oxidation. N. L.

186. *Electrolytic Reductions.* **W. Löb.** (Zeitschr. Phys. Chem. 34. pp. 641–668, Sept. 18, 1900.)—This paper describes some experiments on the general conditions for electrolytic reduction which were made in connection with researches on the electrolytic preparation of benzidin, to be published elsewhere. Much of the work has been anticipated in a paper by Tafel [see Abstract No. 2287 (1900)], with whom the author is in general agreement. Full details are given of the apparatus employed and of a series of experiments on the electrolysis, using a mercury kathode, of (1) an alkaline solution in the absence of any depolariser; (2) in the presence of nitrobenzol; (3) azobenzene; (4) azoxybenzene; and of acid solutions of (5) azobenzene, and (6) azoxybenzene, these substances being intermediate stages in the reduction of nitrobenzene to benzidin. Stress is laid on the great advantage of mercury kathodes in electrolytic reductions.

The latter part of the paper consists of a reply to Haber's criticisms [Abstracts Nos. 1332 and 1333 (1900)], and the view is maintained that in alkaline solutions the reduction is effected by means of the sodium ions. N. L.

187. *Production of Nitric Acid from Air by the Electric Flame.* **A. McDougall** and **F. Howles.** (Manchester Lit. & Phil. Soc., Mem. 44. 13. pp. 1–19, 1900.)—The authors, after briefly summarising in chronological order the ancient methods for the preparation of this acid, enumerate the present improved methods of production by high-tension electrical discharges.

One of the first attempts appears to have been made in 1859 by Newton, whose apparatus consisted of a number of platinum wire terminals between which electric sparks passed, the terminals being contained in a large chamber, the floor of which was covered with water absorbed the oxides of nitrogen with the subsequent production of nitric acid. W. Crookes in 1892 employed a high-tension alternating current discharge between platinum terminals, depending for its maintenance upon the combustion of atmospheric nitrogen and oxygen. A flame of this nature was utilised by Rayleigh in a research on "The Oxidation of Nitrogen Gas."

A fully detailed description of the electrical arrangements follow, well illustrated with photographs and sketches. Readings of the power consumed in producing the flame are then given, the duration of the experiment being 9 hrs. 30 mins. with a resultant yield of 35 grms. of nitric acid, the average number of watts used in the flame being 172. The combustion chamber utilised in these experiments underwent several modifications before a final form was decided upon. The first consisted of a large glazed earthenware pipe, 76 cm. in length and 20 cm. in diameter, supported horizontally, both ends being closed by slabs of slate.

Air was supplied to the flame by a glass tube at one end, a tube at the other end conveying the oxides of nitrogen to the condensing apparatus, the gases being drawn through the whole system by means of a powerful pump. With this apparatus it was found that an expenditure of 220 watts operating for 20 hours produced 38·44 grms. of nitric acid per h.p. per 12 hours.

It was next decided to substitute a combustion chamber of form and capacity different from the one already in use, a stoneware bottle, 30 cm. in height and 10 cm. in diameter, being employed. The rate of oxidation in this apparatus far exceeded that in the previous one. In an experiment extending over 11 hours 48·76 grms. of nitric acid were produced for a continuous expenditure of 227 watts. This is equivalent to 180 grms. per h.p. per 12 hours, or almost twice the quantity produced in the first apparatus. The vessel finally assumed a form similar to that of a lamp-glass of conical structure, the first experiment conducted in this apparatus extending over a period of 22¼ hours, the power continually used being 225 watts. The production of nitric acid proceeded at the rate of 270 grms. per h.p. per 12 hours, thus showing an increase of 60 grms. over and above the quantities obtained in the former experiments. It appeared that too great an increase in the air supply diminished the oxidation, and the oxides of nitrogen, being in a state of greater dilution, were more difficult to absorb. On the other hand, if the air supply was deficient the oxides remained for too long a period under the influence of the flame, and probably suffered a partial dissociation, and a diminished yield of nitric acid therefore resulted. A maximum output was obtained by decreasing the high-tension current, so that only 0·15 ampere was used to feed the flame, 55 grms. of nitric acid being produced in an experiment extending over 9¼ hours. This is equivalent to 300 grms. per h.p. per 12 hours, showing an increase over the quantities produced in all former experiments. A discussion upon the effects of temperature, voltage, air supply, &c., is supplemented. O. J. S.

188. *Polarisation and Current Density in Solid and Fused Salts.* **A. Gockel.** (Zeitschr. Phys. Chem. 34. pp. 529–558, Sept. 7, 1900.)—The complications due to changes of concentration in solutions are avoided by using solid or fused salts, but the very slow depolarisation makes it difficult to work with decreasing current densities, and increasing currents were therefore used. The relationship between current density and polarisation has been investigated in the case of sodium nitrite, sodium nitrate, lead chloride, bromide, and iodide, cadmium iodide, bismuth bromide, and mercuric iodide. The values were calculated from Wiedeburg's formula, $p = \frac{Pi}{2 + K}$, where P is the maximum polarisation, p the polarisation at current density i, and K a constant; and also from Planck's formula, $p = a + \gamma \log i$, which is based on the assumption that the electrolyte is saturated with the products of electrolysis. In some cases there is a good agreement between the observed and calculated values, but usually there are considerable deviations, showing that complications ensue, due to chemical action of the products of electrolysis on the electrodes, secondary chemical changes in these products, and other causes. T. M. L.

189. *Extraction of Zinc.* **L. Belloc.** (Elettricità, Milan, 19. pp. 593–596, Sept. 22, 1900.)—The paper contains descriptions of three patents taken out by Canova and Bertani and one by Casaretti and Bertani, the first for the production of zinc white, and the three others for the production of metallic zinc in the electric furnace.

The last process is worked by the Società Elettro-metallurgica Lombarda.

To produce 1 kg. of zinc 2 h.p. hours are required, and the consumption of coal in the furnace is 15 kg. per 100 kg. of ore. G. H. B.

190. *Comparison of Water, Steam, and Gas Power for Electrochemical Purposes.* **O. v. Miller.** (Zeitschr. Elektrochem. 7. pp. 172–186; Discussion, pp. 186–188, Oct. 11, 1900. Report of a paper read before the Deutsche Elektrochemische Gesellschaft at the Zurich Meeting.)—The author opens this very lengthy paper by stating that in recent years German, Swiss, and Austrian electrical engineering firms have equipped water-power stations with an aggregate capacity of 200,000 h.p. for electrochemical industries. In spite of this fact, opinions regarding the ultimate economy of water as a source of power vary, and many authorities still maintain that nearness to markets and to the supplies of raw materials are more important than cheap power. The author in his paper has sought to calculate the ratios between the costs of power when generated by water, steam, and gas. He has limited his inquiry to large installations running continuously, these being the conditions obtaining when power is used for electrochemical purposes.

As regards water the outlay upon a fall 80 metres high, with a discharge of 7½ cubic metres per second, and with natural advantages for development equal to those found at Matrei, is selected for the comparison, and the calculations for steam and gas are based on power-stations of equal capacity—namely, 6,000 h.p.

The water-power station is supposed to contain six 1,200-h.p. turbines, and a supplementary estimate gives the cost of such a station containing five 1,200-h.p. turbines, with two 1,200-h.p. steam engines as reserves. The estimates for the steam-power station are based upon five 1,500-h.p. generating units, and for the gas-power station upon seven 1,000-h.p. units. The figures obtained are summarised in two tables, which are reproduced below.

CAPITAL COSTS FOR 6,000-H.P. INSTALLATIONS (IN MARKS).

	I. Water Power alone. 6 × 1,200 h.p.	II. Water Power with Steam Reserve. 5 × 1,200 + 2 × 1,200 h.p.	III. Steam Power, 5 × 1,500 h.p.	IV. Gas Power. 7 × 1,000 h.p.
I. *Capital outlay per h.p.*	Marks.	Marks.	Marks.	Marks.
1. At the shaft of the primary motor............	267	347	300	320
2. At the shaft of the secondary motor, 10 km. distant	504	617	550	571
II. *Capital outlay per kw.*				
1. At the switchboard of the central generating station	467	599	517	545
2. At the switchboard of the sub-station, 10 km. distant—				
(*a*) As alternating current supply	603	746	660	688
(*b*) As direct current supply	850	1,022	920	952

RUNNING COSTS PER YEAR (46,000,000 H.P. HOURS) IN PFENNIGE.

	I.	II.			III.			IV.		
		With Coal at pfennige per kg.						With Gas at pfennige per cm.		
		0·2	0·3	0·4	0·5	1·0	1·5	0·10	0·20	0·30
I. *Running Costs per effective h.p. hour.*										
1. At the shaft of the primary motor	0·29	0·61	0·71	0·81	1·11	1·61	2·11	1·00	1·35	1·70
2. At the shaft of the secondary motor, 10 km. distant	0·65	1·08	1·20	1·33	1·70	2·32	2·95	1·55	1·99	2·43
II. *Running Costs per kw. hour.*										
1. At the switchboard of the central generating station	0·59	1·08	1·23	1·37	1·79	2·52	3·25	1·61	2·12	2·63
2. At the switchboard of the substation, 10 km. distant										
(*a*) As alternating current supply...	0·74	1·26	1·42	1·57	2·04	2·83	3·62	1·85	2·41	2·96
(*b*) As direct current supply	1·16	1·79	1·98	2·17	2·72	3·67	4·62	2·48	3·14	3·80

J. B. C. K.

191. *Stirrer with Gas-tight Joint for Electrolysis.* **W. Löb.** (Zeitschr. Elektrochem. 7. pp. 117–119, Sept. 6, 1900.)—This is a description of a simple and convenient arrangement for electrolytic work when constant stirring of the electrolyte is required. Two forms of apparatus are given consisting in the main of broad cylindrical glass vessels fitted with rubber corks, through which the stirring arrangement passes, the bottom joint being formed by a mercury trap. In the one case the stirrer is fitted with a metallic covering of nickel or copper wire netting which serves as an electrode. The article is accompanied by illustrations. O. J. S.

192. *Commercial Electrolytic Manufacture of Hydrogen and Oxygen.* **M. U. Schoop.** (Zeitschr. Elektrotechn., Wien, 18. pp. 441–445, Sept 9, 1900.)—After pointing out the difficulties met with in constructing a suitable commercial apparatus for the manufacture of hydrogen and oxygen, and drawing attention to the necessity of producing pure gases, the author proceeds to enumerate various uses the flame of these gases may be put to, such as lead-burning, limelight, and the soldering of cast iron, &c. A list of various places and description of patents is then given dealing with the electrolytic manufacture of hydrogen and oxygen. The author's own apparatus is described as working without a diaphragm, and using dilute sulphuric acid as an electrolyte and lead electrodes. In order to produce 1·5 cubic metres 11 h.p.

hours are required, which is, according to the author, much cheaper than the generation of hydrogen and oxygen by purely chemical means, such as, for instance, zinc and acid. O. J. S.

193. *Electrolytic Oxidation of Organic Substances by Chromic Acid.* **F. Darmstädter.** (Elektrochem. Zeitschr. 7. pp. 131–133, Sept., 1900.)—In the oxidation of organic substances by chromic acid the latter is reduced to chromium sulphate, from which chromic acid is usually regenerated by ignition with lime. Instead of this chemical process it is more economical to effect the re-oxidation by electrolysis, and this can be done in presence of the substance to be oxidised, the chromic acid being again used as soon as formed. In this way aniline, when dissolved in the acid chromium sulphate solution, is readily converted by electrolysis into quinone, and ethyl alcohol into aldehyde. The liquid is well agitated during electrolysis, and there is thus no danger of the accumulation of chromic acid in the solution, and the consequent destruction of the organic substance by too vigorous oxidation. N. L.

REFERENCES.

194. *Electrolytic Reduction.* **K. Elbs.** (Zeitschr. Elektrochem. 7. pp. 119–120, Sept. 6, 1900.)—Reference having been made by Tafel to a method for the continuous study of electrolytic reductions by the measurement of unused hydrogen evolved at the kathode, devised and briefly described by the author in 1891 (Journ. f. pr. Chemie) a portion of the apparatus, differing in detail from that employed by Tafel, is now more fully described. A diagram is given in the paper. N. L.

195. *Electrochemical Reduction of Aromatic Mononitro-derivatives in Dilute Alkaline Solutions.* **K. Elbs.** (Zeitschr. Elektrochem. 7. pp. 133–138, Sept. 20; and pp. 141–146, Sept. 27, 1900.)—A classified list of substances and their reduction products. References are given. The paper is only of chemical interest. N. L.

196. *Universal Eudiometer.* **G. H. Woollatt.** (Chem. News, 82. p. 151, Sept. 28, 1900.)—Description of a eudiometer devised to give accurate readings of the temperature, pressure, and volume of a gas through a considerable range of these factors. It is especially suitable for demonstration of the laws of Boyle and Charles, and is fitted with explosion terminals for use in the analysis or synthesis of gases. T. H. P.

197. *Electrosynthesis of Ketones and Diketones.* **H. Hofer.** (Elektrochem. Zeitschr. 7. pp. 144–153, Oct., 1900.)—Full details are given in this paper, which is chiefly of chemical interest, of the production of diacetyl by the electrolysis of a solution of potassium pyrotartrate, and of the preparation by similar means of acetone from a mixture of pyrotartrate and acetate, methylpropylketone from a mixture of pyrotartrate and butyrate, 2 : 7-octanedione from potassium levulinate, and acetonylacetone from a mixture of potassium pyrotartrate and levulinate. N. L.

198. *Goldschmidt Method of Producing High Temperatures.* **E. F. Lange.** (Engineering, 70. pp. 450–452, Oct. 5, 1900. A paper read before the Paris Meeting of the Iron and Steel Institute.)—The various applications of this process are described [see further Abstract No. 1950 (1899)]. J. B. C. K.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

199. *Wigzell's Steam Engine.* (Engineering, 70. pp. 311–314, Sept. 7, 1900.)—This is a vertical triple expansion engine, in each cylinder of which there are two pistons moving in opposite directions. Three cranks are used, the middle one connected with the three lower pistons by means of a triangular connecting-rod, and the outer ones each operated by the three upper pistons in a similar manner. This arrangement results in a considerable economy of space for the power developed and a reduction of vibration to practically nothing; there is also a notable diminution of the pressure between the shaft and the bearings which should increase the mechanical efficiency considerably as compared with the ordinary type. A detailed report by W. E. Dalby is given, and includes complete diagrams of the crank-effort and an analysis of the balancing of the engine. H. R. C.

200. *Test of a Triple-expansion Pumping Engine.* **W. F. M. Goss.** (Mech. Eng. 6. pp. 9–13, July 7; and 131–132, July 28, 1900. Abstract of a paper read before the American Society of Mechanical Engineers, May, 1900.)—A twelve-hour trial, during which the i.h.p. was 782·9, and the steam consumption 11·38 lbs. per i.h.p. hour. Steam pressure, 155 lbs. per square inch; piston speed, 212 feet per minute. Pump, h.p., 736.3. Drawings, complete indicator diagrams, and data of the trial are given. H. R. C.

201. *Smoke Density Indicator.* (Amer. Electn. 12. pp. 426–427, Sept., 1900.)—This instrument was exhibited by the Austrian Society of Steam-boiler Owners of Vienna at the Paris Exhibition. It consists of a straight tube 1·6 to 2 inches diameter and 40 inches long, closed at both ends by circular discs of glass. A small branch tube at each end permits a sample of the gases from the combustion chamber of the boiler to be continually passed through the straight tube. An incandescent, electric, or other lamp is placed at one end of the tube, and a funnel with a disc of glass at the other end enables the light to be observed without interference from extraneous illumination. The smaller end of the funnel, in which the glass disc is fitted, is larger in diameter than the straight tube, and is connected to a tube of this larger diameter placed concentrically outside the other, thus forming an annular space surrounding the smoke-tube. The light shines without obstruction through this annular space, whilst in the smoke tube it is more or less obscured, according to the density of the gases admitted there from time to time. The ring-shaped portion of the glass disc of the funnel corresponding to this annular space is divided into six sectors, one of which is left clear whilst the other five are shaded, each with a different shade of grey, according to Ringelmann's scale of the degrees of intensity of smoke; so that on looking through the apparatus the density of the smoke in the central tube may be at once compared with the shade of one of the sectors surrounding it. It is expected that this instrument will enable the fireman or stoker to regulate the admission of air according to the varying stages of combustion, and thus to prevent loss of heat.

The following table is given to show the loss caused by excess of air. An admission of 1·8 times the theoretical quantity required for complete combustion is taken as normal, the loss of combustible being considered as nil at this ratio.

Ratio of admitted air to theoretical quantity	1·3	1·5	1·9	2·4	3·2
Surplus beyond 1·3 times the theoretical	0%	15%	46%	85%	146%
Loss of heat in flue gases	12 „	14 „	18 „	23 „	30 „
Loss of combustible	0 „	2 „	6 „	11 „	18 „
Proportion of carbon dioxide in flue gases	15 „	13 „	10 „	8 „	6 „

F. J. R.

202. *Purification of Feed-water.* **J. A. F. Aspinall.** (Railroad Gazette, 32. pp. 569–570, Aug. 24, 1900. Abstracted from "Report on the Question of the Purification of Feed-water of Locomotives and the use of Disincrustants (Subject XV. for Discussion at the Sixth Session of the International Railway Congress)".)—The following questions were sent out by the general manager of the Lancashire and Yorkshire Railway to ascertain the practice of the different railways of the world:—(1) What process have you for softening or purifying water? (2) Give particulars of the process, materials used, &c. (3) What is the cost of softening per 1,000 English gallons? (4) Give an analysis of the water before and after treating. (5) What is the nature of the scale produced from your unsoftened waters? (6) If possible, give an analysis of the scale and the water producing it. (7) Do you insert any material into your boilers for the prevention of scale? If so, of what does it consist? (8) Are you troubled with pitting of boilers or tubes? (9) To what do you attribute the pitting action? (10) In what part of the boiler does the pitting occur, and what is its condition as regards scale? (11) In what part of the boiler does the feed-pipe deliver? Do you notice any increase of pitting at this point? (12) What metals are used in the construction of (*a*) Boiler barrel, (*b*) Firebox, (*c*) Tubes? (13) What lubricant is in use for cylinder lubrication? (14) Have you used zinc blocks or plates for the prevention of scale? (15) How are these attached to the boiler, and what results did you obtain? (16) What is your method of washing out boilers? Is cold or hot water used? (17) If hot water is used what is its temperature and in what way is it heated?

Table I. gives a summary of those replies to the first four questions in which the cost is stated.

TABLE I.

Countries.	Number of Roads Replying.	Number of Roads using Purifiers.	Average cost per 1,000 English gallons (Cents).
Argentine	2	1	12·0
Austria-Hungary	6	5	7·0
Belgium	3	1	1·6
France	8	6	4·7
Great Britain	22	7	2·0
Italy	3	1	1·3
Norway	1	0	...
Netherlands	3	1	1·1
Russia	4	1	27·2
Spain	1	1	5·0
United States	5	1	3·3

TABLE II.

ANALYSES OF WATER BEFORE AND AFTER TREATMENT.

	Argentine.		Hungarian State.		French State.		Eastern of France.		London & N.-Western.		Midland.		Netherlands State.		Vladikavkaz I.		Vladikavkaz II.		Southern Pacific.	
	Before.	After.	Before.	After.	Before.	After.	Before.	After.	Before.	After.	Before.	After.	Before.	After.	Before.	After.	Before.	After.	Before.	After.
Calcium Carbonate	10·78	2·52	14·35	6·23	10·15	3·50	21·21	6·02	17·3	1·4	8·46	2·47	18·76	5·74	9·0	Nil.	...	...	17·15	0·80
„ Sulphate............	2·03	Nil.	11·76	...	5·25	0·98	10·51	...	1·1	1·0	3·65	Nil.	8·82	7·84	19·41	7·63	39·19	6·02	6·08	0·35
„ Nitrate	2·87	Nil.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Magnesium Carbonate ...	7·35	5·74	12·11	11·41	5·74	1·05	9·38	7·91	0·8	0·6	1·05	0·21	...	...	6·17	Traces.	22·34	Nil.	1·46	7·15
„ Sulphate	...	...	...	...	2·17	0·84	...	...	...	...	2·89	1·74	11·34	11·34	...	...	25·15	24·94	20·58	1·95
Sodium Carbonate	Nil.	7·07	...	...	...	...	...	...	...	...	...	...	...	...	...	10·44	...	34·13	...	...
Silica, &c.	2·52	3·08	0·91	0·77	...	...	...	...	0·3	0·1	...	...	...	...	...	...	...	...	1·81	0·33
Alkaline Salts..................	...	...	...	...	...	...	...	18·97	...	...	...	...	...	...	...	...	...	...	14·77	40·35
Total scale-forming matter	21·0	9·5	54·46	47·60	...	...	47·88	37·8	19·5	3·1	13·16	2·68	...	...	...	...	...	...	47·08	10·58
Total dissolved solids at 212° F......................	...	...	...	...	...	...	...	...	23·0	6·5	22·30	14·30	...	...	...	...	...	...	...	...
Total solids dried	...	...	...	...	...	...	...	...	...	...	...	...	...	...	70·84	50·40	217·56	221·06	61·85	50·93
Total hardness	25°	9·8°	37·2°	19·7°	31°	8°	46·2°	15·4°	21·2°	3·6°	14·7°	4·2°	34·7°	...	30·6°	5·6°	74·2°	24·5°	40·41°	11·25°
Permanent hardness	...	...	13·6°	...	29°	8°	21·7°	8·4°	3·6°	1·6°	...	...	21°	...	14·3°	5·6°	47·6°	24·5°	21·51	9·38°

The above results are expressed in grains per gallon. The degrees of hardness are English degrees.

Processes used.—The *Buenos Ayres Great Southern Railway* (Argentine Republic) use the Tyacke apparatus, softening 2,000 gallons per hour by the addition of a fixed quantity of quicklime and caustic soda to the water per hour.

The *Hungarian State Railway* uses the Beranger-Stingl and also the Pollacsek apparatus, the reagents being soda and lime.

The *French State Railroads* use three systems—(1) An intermittent system, a quantity of water being mixed with lime and carbonate of soda, and filtered after settling for twelve hours. (2) Beranger-Stingl purifier. (3) Gaillet purifier.

The *Eastern of France.* Up to 35 degrees of hardness soda is used, above that milk of lime is added separately to precipitate bicarbonate of lime.

The *London and North-Western* uses Clark's process, with modifications by Porter and Howatson, lime alone or with sodium carbonate being added, with subsequent filtration or subsidence.

Midland Railway (England) uses the Archbutt-Deeley process, employing as reagents lime and sodium carbonate.

Netherlands State Railroads. A solution of soda is added to the feed-water in the proportion of 35·27 lbs. per 22,000 gallons of water.

Vladikavkaz Railroad (Russia). The Beranger-Stingl apparatus or a modification is used, with caustic soda solution as the reagent. The analyses I. in Table II. show the results on water containing small quantities of magnesium salts, and analyses II. show the effects on water containing large quantities.

Southern Pacific Railway uses a process based on the chemical principles of the Porter-Clark process, concentrated solutions of the reagents being injected into the main feed supply.

The analyses of the water used on these railways before and after treatment are given in Table II.

The Southern Railway of Austria uses the Beranger-Stingl apparatus, with milk of lime and soda, the analysis of the water before and after treatment being given as follows :—

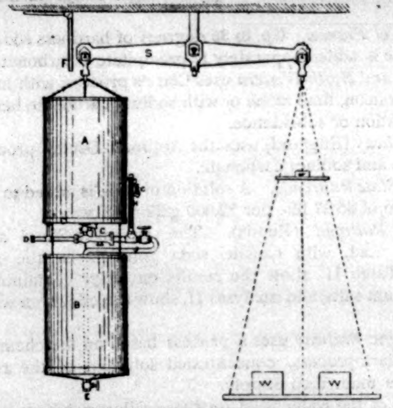
Lime	Before treatment	13·72	After	1·4
Magnesia	„ „	8·61	„	3·7
Combined Carbonic Acid......	„ „	13·02	„	1·0
Total hardness	„ „	44·64°	„	11·7°

Apart from preliminary treatment of the water, several railways use disincrustants in the boilers or tanks of locomotives. Various substances are used. The Report must be consulted for a list of these, and also for the very full replies received on the subject of pitting and its causes.

Twenty-six railways out of 63 use hot water for washing out the boilers, the hot water being of from 120° to 140° F., and 37 use cold water. F. J. R.

203. *Steam Calorimeter.* **J. Goodman.** (Elect. Engin. 26. pp. 337–339, Sept. 7, 1900. Paper read before the British Association.)—Recent work having shown that the specific heat of superheated steam—upon which the wire-drawing steam calorimeter depends—is not even approximately constant, or in accordance with any ascertained definite law, the author has devised the new form of the condensing calorimeter shown in the figure.

The scale beam S is about 42 inches long, and will turn with 0·01 lb. when weighing 120 lbs. The tank A is filled with water from the pipe F until the weights in the large scale pan (W_1) are just balanced, tank B being empty. The temperature of the water in A is accurately measured (t_1), and then the sample of steam to be tested is admitted through the pipe D and mixes in the injector C with the water on its way from A to B. The mixture passes a thermometer H, which is read every 10 or 15 seconds (t_2), and is delivered through the pipe J to the bottom of tank B. When A is nearly emptied, steam and water are cut off, and the weight of steam taken is found by placing weights (w) in the small scale pan until the balance is restored. Tap E is then opened, and tank B allowed to drain, after which balance is again made by replacing W_1 by W_2 [w being removed]. $W_1 - W_2$ gives the quantity of water mixed with the steam; then—



$$w(xL + t - t_2) = (W_1 - W_2)(t_2 - t_1).$$

The author considers that the fairest way of taking the sample from a horizontal main steampipe is by a perforated pipe along a vertical diameter, as this catches the film of water which creeps along the bottom of the main pipe. It is also stated that the accuracy of a steam calorimeter may be checked by testing a sample from a vertical steampipe immediately over a boiler from which no steam is flowing except that required for the sample, as such steam would be perfectly dry. H. R. C.

204. *Disposal of House Refuse in Bradford.* **J. McTaggart.** (Elect. Rev. 47. pp. 415–417; Discussion, pp. 417–418, Sept. 14, 1900. Abstract of a paper read before the British Association.)—The population of Bradford is estimated at 292,800; the acreage is 22,843; the average number of people per acre 12·8, and the rateable value is £1,396,067 7s. 6d. The total quantity of refuse collected is 125,000 loads per annum from 32,164 ashpits, to which 180,000 visits are paid, giving an average of 3·87 loads per ashpit and 5·6 visits per annum to each.

At the present time about 90,000 loads are destroyed annually at the destructors, the remainder being either tipped in the out-districts or sold to farmers. The total number of destructor cells is 53, being 29 at work, 6 rebuilding, and 18 to be erected. These when complete will have a total destroying capacity of 145,000 loads per annum.

The destructors are of the Horsfall pattern, each one consisting of two blocks of six cells of the back-to-back type, with two 11 feet by 8 feet multitubular boilers, the chimney being placed between the two blocks. Each block of cells has a flue leading to one of the boilers and an alternative flue leading to the chimney. Some improvements in details of construction have been introduced, and air flues have been made under the tipping-floor, which keep it cool by the induced current of air passed through them by means of a steam-jet. An overhead railway is also provided for the removal of the clinker. A working test of the destructor gave the following results :—

TEST OF THE HORSFALL DESTRUCTOR, JUNE 24 TO JULY 7, 1900.

Number of cells : 12.
Type : Back to back.
Duration of test : 278 hours.
Nature of fuel : Midden, market and dry refuse.
Number of men employed : 12 furnace men, 6 chargers.
Wages : Furnace men, 28s. ; chargers, 25s.
Total quantity of refuse burned : 2,896,320 lbs. = 1,293 tons.
„ „ „ per cell per 24 hours : 20,837 lbs. = 9·3 tons.
Total cubic feet of refuse burned per cell per 24 hours : 543.
Total quantity of refuse burned per square foot of grate per hour : 34 lbs.
„ „ „ per cell per hour : 868 lbs.
Cost of labour per ton destroyed : 9d.
Total weight of water evaporated : 2,153,000 lbs.
„ „ „ per hour : 7,744 lbs.
„ „ „ per cell per hour : 645 lbs.
Water evaporated per lb. of refuse burned : 0·743 lbs.
„ „ „ „ from and at 212° F. : 0·882 lbs.
Weight of clinker produced : 817,516 lbs. = 364·96 tons.
„ fine ash „ 26,936 „ = 12·02 „
„ fine dust „ 5,992 „ = 2·67 „
Total weight of residuals : 850,444 lbs = 379·65 tons.
Percentage of residuals : 29·36 per cent.
Steam pressure maintained (by recorder) : 60 lbs.
Temperature of feed-water : 60° F.
„ gases in main flue : 1,800° F.
„ „ at bottom of chimney : 1,000° F.
Average air pressure (water gauge) : ⅞ inch.
Total I.H.P. per hour at 20 lbs. : 387·2.
„ per cell continuously : 32·2.
I.H.P. hours per ton burned : 83·2.

The main importance of the installation lies in the arrangements for turning the residuals to profitable account. The steam produced is partly utilised in driving eight mortar mills, which turn out mortar at the rate of 12,000 tons per annum, and for working hydraulic machines, which are used in the production of artificial stone slabs for paving. Concrete bricks, consisting of a 10 per cent. mixture of hydraulic lime and clinker, are also manufactured at a cost of 14s. per 1,000. A small machine turning out 8,000 bricks per day requires over 20 tons of clinker for that purpose; and the manufacture of ornamental tiles from the same material is being commenced. Sifted clinker of various grades is also disposed of by sale, and old tins, scrap iron, &c., go to chemical works, scrap merchants, and others. In addition to the machinery above mentioned there is a complete plant for the manufacture of artificial guano from the fish refuse, of which from 600 to 700 tons are dealt with annually and reduced to 25 per cent. of its original bulk, making a profitable product which is sold at £3 per ton.

The new destructor being erected will reduce the labour for tipping and charging, and is expected to reduce the labour cost of destroying the refuse to 5½d. per ton.

The following statement shows how the power generated during the fortnight's trial recorded above was utilised, and the returns from it:—

	£	s.	d.
306 tons 13 cwts. 2 qrs. of mortar made and sold, value ...	82	8	6
442 tons of crushed clinker sold, value..........................	14	14	8
245 sq. yds. of concrete flags manufactured, value...........	38	15	10
3 tons 3 cwts. 3 qrs. old tins sold, value	0	15	11
About 4 tons of fish guano manufactured, value	12	0	0
	£148	14	11

Discussion.—**C. E. Webber** alluded to the project of combining destructor works at Kensington with plant for generating electricity for distribution, upon which he had reported some years ago. He found that the calorific value of London refuse was too low to permit of such a project being worked economically, but **G. Watson** pointed out that the development of electric tramways now introduces a profitable day load for electric installations. **J. McTaggart,** however, in reply, considered it the better plan always to have complete electric plant apart from destructors, since the calorific value of the refuse varies greatly from day to day, and the steam power can be profitably utilised in the other directions indicated. F. J. R.

GAS AND OIL ENGINES.

205. *Efficiency of Port Valves of Internal Heat Engines.* **H. D. Meier.** (Horseless Age, 6. pp. 13–15, Sept. 19, 1900.)—The author deals with experiments on a small internal-heat engine, arranged so that it could be driven at any speed between 100 and 350 r.p.m. from an external source of power. An indicator having a spring graduated at 15 mm. to 1 atmosphere was connected to the engine cylinder, and cards taken. These show that during the suction stroke, with either the admission valve held full open and exhaust valve operating, or *vice versâ*, a vacuum is formed, and considerable back pressure exists on the exhaust stroke. Diagrams showing these features were obtained even when both valves were held full open. The author points out that this is the only satisfactory way of arriving at a knowledge of the sufficiency or otherwise of the ports and valves in high-speed engines, and calls attention to the fact that certain indicator cards of a 125-h.p. gas engine taken by C. H. Robertson [Abstract No. 898 (1900)] show back pressure and partial vacuum even with 100 and 160-lb. springs. C. R. D'E.

206. *Compressed Air Motors.* **H. D. Cooke.** (Street Rly. Journ. 16. pp. 879–880, Oct., 1900. Paper read before the New York State Street Railway Association, Sept., 1900.)—After stating that nothing has yet been accomplished in the manufacture of liquid air which will warrant its consideration for operating street railways, the author deals with the latest compressed-air cars now in use in three cities in the United States. Those now employed by

the Metropolitan Street Railway Co. of New York are fitted with two engines, each directly connected to one pair of wheels. The one pair of wheels is connected to the other pair by connecting rods. The air passes from storage tubes to the engines through a reheating water tank, the initial temperature of which is 300°. This reheating is shown by experiment to nearly double the mileage of the car; with cold air a 35-cubic-feet storage ran a car eight miles, and the same car ran fifteen miles, using the reheater. A controller of simple form varies the cut-off from one-tenth to five-eighths of the stroke, and gives all other necessary regulations. An air-brake and a special starter are fitted to the cars, both of these being controlled by a single lever. Other cars have now been used in Chicago for sixteen months on night duty; they sometimes haul two trail cars, and have proved successful in all weathers. The storage tubes are of mild steel, tested to 5,000 lbs. per square inch; they work at an initial pressure of 2,000 lbs., and are charged from a stationary battery of similar tubes. The tubes in the power-house are charged to a pressure of 2,500 lbs., and they recharge the car tubes in about two minutes. The air passes through a reducing valve before entering the reheater, and its pressure is then 150 lbs. per square inch. The exhaust from the engine never falls below 70°. When compressing the air originally its temperature is reduced to that of the atmosphere by a water-jacket system; all moisture is removed by a separator, through which it passes on its way to the storage battery. The Chicago cars consumed, during six months' working, an average of 409 cubic feet of free air per car mile; the weight of the car is not given. It is estimated that the cost of compressing 1,000 cubic feet of free air to 2,000 lbs. per square inch is 2·8 cents; in this figure coal is taken at $2.90 per ton, 2 lbs. of coal per i.h.p. per hour; labour, sundries, and 10 per cent. depreciation are included. A. G. N.

207. *Collin-Dufresne Ignition Apparatus.* (Locomotion Automobile, 7. pp. 597–598, Sept. 13, 1900.)—This article describes a form of ignition tube for explosion engines, which depends on the fact that spongy platinum once rendered incandescent will continue so if immersed in hydrocarbon vapour. The platinum ignition tube D is of the kind ordinarily used for petroleum spirit engines. It is surrounded by a second tube T, and the space between is filled with spongy platinum. Air, carburetted by bubbling through petrol, passes under pressure along the tube G. When the cock R is in the position shown, the mixture passes along the tube N, and being ignited at U raises the tube T, and the spongy platinum to a bright red heat. The cock R is then turned so that the hydrocarbon vapour proceeds along G, coming into contact with the spongy platinum, which continues to glow, although the flame at U has been extinguished. The inner tube D is thus heated to incandescence for a length which depends on the pressure of gas in G. The point of firing the charge may thus be varied by adjusting the cock R. Two other

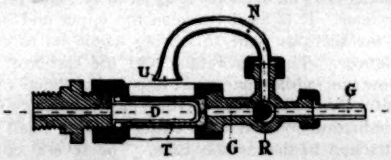


Fig. 1.

illustrations are given, showing the method of generating the carburetted air, and the application of the complete apparatus to a petrol engine.

C. R. D'E.

208. *Bournonville Acetylene Generator.* (Eng. News, 44. pp. 234–235, Oct. 4, 1900.)—A gas generator of the type in which the carbide is automatically fed into the water. A toothed drum conveys the carbide from a closed hopper into a vessel holding water. The feeding drum is caused to revolve when a gas-holder, forming part of the apparatus, begins to fall. The mechanism employed for this purpose consists of a system of levers connecting the floating holder with a pawl, which actuates a toothed wheel on the drum spindle. The carbide drops from the drum through the water inside a chamber provided with deflector plates, which prevent the gas from rising inside this chamber. A pipe leads from the top of the generating vessel, through a small trap, to a condensing chamber, and from there the gas passes through a filter to the floating gas-holder. Blow-off pipes are provided for the carbide chamber, the condensing chamber, and the gas-holder. The bottom of the generating vessel is fitted with a scraper which can be revolved by hand; a discharge valve and flushing-pipes are also provided for thoroughly cleaning out this vessel. A sectional drawing, showing the arrangement of the various parts, accompanies the original description.

A. G. N.

AUTOMOBILISM.[1]

209. *Marsh Motor Cycle.* **A. R. Marsh.** (Scientific American, 83. pp. 100–101, Aug. 18, 1900.)—Describes a compact form of motor bicycle in which a small petrol motor is attached to the seat-post tube of an ordinary diamond frame, and drives the rear road wheel by means of a single reduction chain gear. The motor in general design closely resembles the air-cooled motors of de Dion and Bouton. It has a single vertical cylinder bolted to a crank case, in which the flywheel crank revolves, oiled, and protected from dust. The motor is stated to weigh only 20 lbs., it is 14 in. high × 4 in. wide overall, the cylinder is 1⅞ in. diameter × 2¼ in. stroke, and drives the bicycle at 30 miles per hour. It is fixed between the upper and lower stay tubes, and in front of the seat-post tube, this being employed to lead the exhaust gases to the silencer. The petrol tank and the carburettor are attached behind and below the saddle; one quart of petrol is stated to suffice for 100 miles. The ignition of the explosive mixture in the motor cylinder is effected electrically, an induction coil and a dry battery of very small dimensions and weight being attached to the top stay tube. The several control levers are also attached to this tube. A free-wheel chain driver is employed to start the bicycle. The total weight is 60 lbs.

C.R.D'E.

210. *Working Costs of Automobiles for Street Watering and Dust Removal.* **E. Shrapnell Smith.** (Automotor Journal, 4. pp. 628–629, Sept., 1900. Excerpt from a paper read before the Association of Cleansing Superintendents of Great Britain, Aug. 30, 1900.)—This paper contains analyses of the results obtained with steam motor vehicles for cleansing purposes. From figures supplied by A. Ramsden, surveyor, of Chiswick, the horse contractor's tender for the year ending March 31, 1898, was £1,900, whereas the actual cost of doing the work of dust removal in this district with two steam tip-vans was £1,253. From this it is calculated that £1,228 would be saved in three years by the use of steam vehicles, notwithstanding a mean annual increase of 185 houses in the district. J. A. Brodie, city engineer, Liverpool, states that the working of a 4-ton Leyland steam van has proved "satisfactory and highly economical." A similar opinion is stated to be given by T. W. E. Higgens, surveyor to the Chelsea Vestry. The Strand Board of Works has employed a Thornycroft vehicle for dust removal and watering for about six months, with the result that their engineer, A. Ventris, states that this vehicle does the work of three single-horse dust-carts "better and more speedily"; also "it has displaced two water-vans, horses, and drivers. Based on these results the following figures are given, in which the first set give the cost of the carts, &c., discarded, and the second set the cost of working the steam car by which they were displaced :—

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[1] Electric Automobiles are described in the section dealing with Electric Traction.

	£	s.	d.
Hire of five horses and harness (feeding and stabling done by contractors), at £65 per horse	325	0	0
Hire of two water-vans, at £16	32	0	0
Three drivers of dust-vans, at £71 10s.	214	10	0
Two drivers of water-vans, at £84 10s.	169	0	0
Oiling and repairing three dust-vans, at £8	24	0	0
Third-party insurance on five vans	7	10	0
Total reduction in cost per annum	£772	0	0

Dust-vans are owned by Board, and used for other purposes.

The expenditure in respect of the motor has been :—

First Period.—Hire for eight weeks at £7 10s. per week, for day work only, inclusive of all charges.

Second and Third Periods.—These aggregate a clear three months. The appended table, supplied by Mr. Ventris, is in proportion, and may be relied upon as being the outcome of experience.

Estimated Annual Expenditure.

	£	s.	d.
Interest and return of capital, spread over 10 years, say	82	6	0
Fuel—36 cwts. per week, at 32s. per ton	150	0	0
Wages—Two drivers at 37s. per week	192	8	0
Attendant to work levers of water-van on day shift, at 25s.	65	0	0
Repairs—Thornycroft's guarantee	75	0	0
Lubrication and waste	20	0	0
Boiler insurance on £2,000	3	4	0
Third-party insurance	10	10	0
Total cost per annum	£598	8	0

These figures show a saving of £173 12s. per motor car per annum.

C. R. D'E.

211. *Cowles' Variable Speed Gear.* (Automotor Journal, 4. p. 603, Sept., 1900. Drawings from the Motor Age.)—This article describes a gear in which variations of speed are obtained by varying the radius of action

of a pair of friction wheels pressing on either side of a disc. In a motor vehicle the motor drives the friction wheels in opposite directions by means of jointed rods, and the driven disc is mounted on the exterior of a differential gear on a countershaft which drives by single reduction spur gears the independent axles of the road wheels. C. R. D'E.

212. *Capel's Motor Car.* (Automotor Journal, 4. pp. 551–556, Aug., 1900.) —This article describes and illustrates a light petrol car to carry three persons designed especially with a view to secure accessibility and simplicity of mechanism and control arrangements. There is no underframe proper, but several essential parts of the mechanism are built together and suitably sprung from the axles so as to form the support for the carriage body, engine and driving gear.

The engine, which develops 4 b.h.p. at 800 r.p.m. has two horizontal cylinders, each 3-inch bore by 5-inch stroke. It is placed at the back of the vehicle below the principal seats and drives the live rear axle through a combination of leather-covered chain and helical spur gear, giving forward speeds of 4·5, 12, and 20 miles per hour, and one reverse speed. A modified form of Ackerman steering gear is employed which is claimed to be very sensitive and so arranged that the shocks imparted to the wheels cannot act back on the steering lever. The cooling water for the cylinder jackets is circulated by means of a rotary pump and is cooled by passing through a Clarkson radiator placed in the front of the car. Shoe brakes are employed, which act on the tyres of the rear road wheels. C. R. D'E.

REFERENCES.

213. *Stéate Electric Ignition Plug.* (Automotor Journal, 5. p. 31, Oct., 1900.)—This article describes and illustrates a well-designed form of sparking plug for explosion engines invented by Frémy and Mare. The insulating material of the plug is steatite or soap stone, which has a high insulating value, and appears less liable to breakage than the porcelain insulators usually employed in these plugs. C. R. D'E.

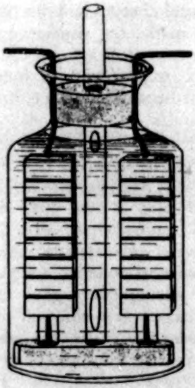
214. *Heavy Automobiles.* **F. W. Maynard.** (Eng. Mag. 19. pp. 825–840, Sept., 1900.)—Descriptions and photographic illustrations of vehicles referred to in Abstracts Nos. 899, 902, 904, and 905 (1900). C. R. D'E.

215. *Automobiles at the Paris Exhibition.* (Automotor Journal, 5. pp. 1–21, Oct., 1900.)

216. "*Thousand Miles*" *Automobile Trial.* **W. W. Beaumont.** (Eng. Mag. 20. pp. 81–98, Oct., 1900.)—The author gives an account of all the principal vehicles competing in the trial, together with practical considerations on the general results. The mechanical efficiencies of the principal cars, as deduced from the hill-climbing and speed trials, are given, and the article is illustrated by numerous photographs [see further Abstract No. 2481 (1900).] C. R. D'E.

GENERAL ELECTRICAL ENGINEERING.

217. *Storage Cells for High-tension Batteries.* **M. U. Schoop.** (Zeitschr. Elektrotechn., Wien, 18. pp. 478–479, Sept. 30, 1900.)—Batteries consisting of a large number of small storage cells are coming more and more in use for cable testing, the standardisation of high-voltage instruments and other purposes. The form shown half full-size in the figure is manufactured by the Kölner Accumulatoren-Werke, G. Hagen, at Kalk, near Cologne. The containing vessel is a wide-mouthed bottle of white glass provided with a rubber stopper. The framework of the electrodes is made in the usual manner, pasted and then formed. The capacity is such that a discharge at the rate of ¾ ampere will cause in an hour a fall of 10 per cent. of the voltage. At the bottom the electrodes are fixed to a glass bridge, and between them is a glass tube with two side-holes for gases to escape and for allowing the addition of distilled water to be easily made, the air passing out of the upper opening. The cells are mounted in sets of 25 in paraffined wooden trays. A photograph of the battery of 2,200 such cells, made for Felten and Guilleaume, of Mülheim, and used for cable-testing at 4,000 volts, is reproduced. The cells are charged by placing the groups in parallel and using a 70-volt dynamo. On short circuit each cell gives 11 amperes with a potential difference of one volt. The 2,200 cells on short circuit would thus correspond with 32 e.h.p. W. W. H. G.



218. *Wehrlin Accumulators.* **H. Wehrlin.** (Zeitschr. Elektrotechn., Wien, 18. pp. 395–397, Aug. 12, 1900.)—The general requirements of a battery suitable for rapid discharge and charge are discussed, and the plates manufactured on the Wehrlin system by the Accumulatoren-Fabrik Wüste and Ruprecht of Baden and Vienna are described. The positive plates have a total available surface of 9–9·5 times the apparent surface and are made of horizontal parallel lamina specially arranged; the negative plates are of the grid type, having pastilles very firmly held. Curves are given confirmatory of the successful design of these plates for buffer battery use. A comparison is also

made of their capacity with others, and the following figures are taken from the curves, where the capacity of each type is compared with its value for a three-hours' discharge :—

	Capacity, Ampere-hours.				
	Time of Discharge in Hours.				
Type.	3	2·5	2	1·5	1
"Fr." Wüste and Rupprecht......	100	96	91·5	83	74
"G.S." Acc. Fabrik Actien-Ges...	100	93	86	79	72
"Ru Rg." Acc. Wrk. Pollak......	100	93·5	86·5	77·5	68
"R.K." " " "	100	91	81	73	64

W. W. H. G.

219. *Formation of Accumulator Plates.* **G. Carro Cao.** (Elettricità, Milan, 19. pp. 707–709, Nov. 10, 1900.)—This paper describes experiments undertaken to determine the variation of capacity and resistance of pasted plates during the period of their formation. The lead plates were immersed in dilute nitric acid, then washed, and made up in their cells with 10 per cent. acid ; after undergoing several charges and discharges they were pasted, and 46 charges and discharges made, the discharge being carried on until the e.m.f. had diminished 10 per cent. below its initial discharge value. Both the capacity and resistance were found to increase regularly during the formation of the plates, but became constant after the fortieth charge and discharge. G. H. B.

220. *Accumulator Charging at Constant Potential.* **C. Heim.** (Elektrotechn. Zeitschr. 21. pp. 269–272, April 5 ; 288–290, April 12 ; 309–312, April 19; 329–331, April 26 ; 347–349, May 3 ; 391–394, May 17 ; 416–419, May 24 ; 438–441, May 31 ; 463–465, June 7 ; 487–491, June 14, and pp. 504–507, June 21, 1900.)—A long series of experiments made by the author to compare the effects of charging at constant potential and with constant current on the capacity and efficiency of accumulators gave the following results. The energy efficiency of cells charged at a constant potential of from 2·4 to 2·5 volts is only about 3 per cent. less than that when charged with constant currents, the time of charge with constant current being 3½–4 hours ; the same charge is given at a constant potential of 2·5 volts in 1½ hours ; two-thirds of the charge is given in ½ hour, and in the latter case the efficiency is about 4 per cent. greater than in the case of the complete charge. In these comparisons the discharge current was kept constant at a value slightly greater than the constant charge current. When discharged at twice this rate the efficiency fell about 3 per cent. In a series of charges and discharges without intermediate pauses, the mean charging current and the capacity increase (in a series of five charges and discharges the increase of capacity was about 15 per cent.). This was found to be due to the increase in the temperature of the cell (amounting in the case mentioned to 12·5° C.), which, according to the author's explanation, diminishes the viscosity of the acid, and thus promotes the diffusion of the acid formed in the pores of the active material. Charging at constant potential causes the fall of more active material than does charging with constant current, owing to the high current density at the commencement of the charge, but the effect diminishes with successive charges. After a series of 70 charges and discharges a loss of capacity of 5 to 6 per cent. was noted. G. H. B

221. *Maximum Demand Indicator.* **J. H. Barker.** (Elect. Rev. 47. pp. 418–419 ; Discussion, p. 419, Sept. 14, 1900. Paper read before the British

Association.)—This instrument is a maximum demand indicator combined with an integrating wattmeter of the motor type employing a magnetic brake device such as the Thomson-Houston meter. The magnetic brake consists of a copper disc revolving in a horizontal plane between the poles of two permanent magnets. The two magnets instead of being permanently fixed are supported on a beam and suspended in such a manner that they tend to follow the rotation of the disc. The suspension is a steel wire enclosed in a tube and fixed at its lower end to the beam and at its upper end to a screw. The torsion of the steel wire acts as a spring and controls the distance through which the suspended system moves. The spring or other controlling force is made comparatively strong in order that the motion of the magnet poles may be so small as not to effect the rate of the meter, and also in order that the period of oscillation of the suspended system may be short.

When there is a sudden increase in the current the magnetic brake would tend to swing beyond the position proper to the new current if the period of oscillation were not short in relation to the time taken by the revolving parts to attain their new velocity. The motion of the brake is multiplied and actuates an indicator. A light ratchet and pawl is fixed at one end of the beam and retains the device at its point of maximum deflection; a lever with a sealing device passes through the outside of the case and enables the meter inspector to re-set the indicator. E. C. R.

222. *Service Joint-box.* **L. Andrews.** (Lightning, 18. pp. 361–362, Oct. 11, 1900.)—The author describes, with illustrations, a joint-box for triple concentric mains invented by J. Glass, which is in use at Hastings. The box costs £1, and a joint can be made with it in a little over half an hour. To avoid frequent cutting of the outer conductors of the cable small installations are coupled to the neutral and outer, only the large ones being connected with the neutral and inner. The box is very compact, and little skill is necessary in its use. A. H. A.

223. *Cable-Making.* **W. Maver.** (Cassier, 18. pp. 467–479, Oct., 1900, and Electrician, 45. pp. 967–969, Oct. 19, 1900.)—Aluminium wire has 1·27 times the diameter of copper of the same conductivity, and hence is little used in covered cables. Red-hot copper ingots of 200 lbs. weight are rolled into rods by passing backwards and forwards through a mill by men at each side. When small enough the rod is passed on from the smaller mills by curved guides and rolled down to No. 7 B.W.G. Before drawing, the wire is covered with flour paste as lubricant. The shell hardness produced by drawing is removed by annealing. Tinning is effected by passing it through a vat of molten tin. In the U.S.A. wires are not stranded unless larger than 0·257 inch diameter (No. 2 B & S gauge). Machines carrying up to 130 reels, each weighing 1,000 lbs., are used for stranding. Crude rubber is bought in balls weighing from 5 to 60 lbs. Washing, by passing the material through a mill soused with water, reduces the weight 20 per cent. This washing is effected after twelve hours' soaking at 200 to 212° F. The material leaves the washer as a rugged sheet, which is dried in air for three weeks. A well-known cable mixing contains :—

Para	15	lbs.
Litharge	4·5	„
Whiting	6	„
Blue lead	4·5	„
Sulphur	7	oz.

Very low-grade rubber may be applied seamlessly through the screw feed-pipe machine and allowed to rest in a bed of talc. It is then coiled on a drum, taped if necessary, and vulcanised in a steam chamber at 250 to 300° F., according to the grade of rubber. The ordinary and better horizontal machine, which applies rubber strip by passing it and the cable through grooved steel rollers, is described. For fibre cables paper is loosely coiled on a wire, the whole is baked till dry, and then immersed in insulating oil. The several conductors of a cable are then stranded together, jacketed with wire insulation, and lead-covered; a small increase beyond 2 per cent. of tin in the lead will double the pressure necessary in the lead press. The highest voltage used in New York on covered cable is 6,600 volts on a 10-mile circuit; the maximum energy in a single circuit transmitted is 2,700 h.p. The thickness of rubber insulation on this cable (0·5-inch diameter) is $\frac{5}{32}$ inch on each member, and a jacket of $\frac{5}{32}$ inch outside the three members. Each member, and also the jackets, are severally taped. Three miles of 25,000-volt underground cables are soon to be operated. The three wires of the cable are No. 2 B & S gauge; the insulation is $\frac{7}{32}$ inch diameter on each, with a jacket of $\frac{5}{32}$ inch. The maximum advantageous pressure for overhead lines is thought to be 40,000 volts. M. O'G.

224. *Cable Faults.* **J. Wright.** (Elect. Rev. 47. pp. 605–607, Oct. 12, 1900.)—Chips of wood from the centres of the rubber rolls escape observation in vulcanised rubber cables, as also cotton threads or jute, but in the case of gutta-percha they are detected by visual inspection. If the wire is not taut in running through the "longitudinal" machine the rolls will sometimes crush off a splinter of copper, which pierces the insulation. The same occurs when a kink passes. Bad longitudinal seams are due to faulty rolls which have not been reground after extensive use. A double lap of pure rubber is recommended. Flattening of the unvulcanised paste by over-tight drumming and taping, broken wires inside an unbroken rubber cover, birdcaging of hard-drawn strands, and lead oxide faults in the lead sheath are remarked on.

M. O'G.

225. *Heating of Electric Cables.* **J. Herzog** and **C. Feldmann.** (Elektrotechn. Zeitschr. 21. pp. 783–788, Sept. 20, 1900.)—The heating of electric cables is here treated both experimentally and theoretically. The experiments were made on single-core cables and three-core concentric cables, the single-core cables having sections of 10 and 100 sq. mm. and the three cores of the concentric cables having sections of 10, 100, and 200 sq. mm. per core in the three concentric cables used. Experiments were also made with a three-core non-concentric cable, each core having a section of 150 sq. mm., this cable in one series of experiments being buried in sand at a depth of 73 cm. and heated by three-phase currents. The experimental results are given in tabular form and in curves in the paper.

The latter part of the paper deals theoretically with the problems of the conduction of heat in cables of different forms and in the earth surrounding a buried cable. [See Abstracts Nos. 1924 and 1925 (1900.)] J. B. H.

226. *Ougrimoff Electric Calorifactor.* **J. A. Montpellier.** (Électricien, 22. pp. 177–179, Sept. 22, 1900.)—The Ougrimoff electric heater (or *calorifactor*, as it is termed by its inventor) is primarily intended for factories which are driven electrically with the aid of water-power, but require steam for heating purposes, as, for example, sugar refineries or distilleries. It consists of a cylindrical vertical boiler with a hermetically closed concentric cast-iron tube inside. An arc is caused to play between a powdered graphite lining to the tube and a carbon rod suspended within it, the rod being passed air-tight through a cover and insulated from the rest of the apparatus. The carbon rod must always form the positive electrode, and, in use, it is screwed down until it touches the graphite lining of the tube, and is then raised to strike the arc, the resistance of the cold powdered graphite being so great that no short-circuit is caused at the moment of contact. The graphite serves the further purpose of protecting the metal of the tube from becoming overheated afterwards. During action graphite is constantly being deposited in the tube, being transferred from the carbon rod (at the rate of 2 grm. per hour with an arc of 60 amperes at 60–80 volts), so that any loss of graphite by combustion is compensated for. A small valve allows for the escape of gas owing to expansion at the moment of starting. An Ougrimoff boiler in the Paris Exhibition (1900), 40 cm. high and 18 cm. in diameter, consumed 6 to 10 kw. (100 amperes × 60 to 100 volts) per hour and gave steam at a pressure of 7 kgrm. per sq. cm., the efficiency being stated as 98 per cent. To compare with ordinary usage the author makes a calculation purporting to show that the cost of a calorie produced by steam heat in a part of a factory at a distance from an ordinary boiler may be 0·26 centime, whilst that of a calorie produced by the calorifactor is 0·17 centime, valuing electrical energy at 1·5 centimes per kw.-hour. W. G. M

227. *High-Tension Condensers.* **L. Lombardi.** (Elettricità, Milan, 19. pp. 628–630, Oct. 6, 1900. Paper read before the International Electrical Congress at Paris.)—The author has found a method of preparing paraffin wax sheets which, though thin, are perfectly homogeneous. Sheets 36 × 49 cm. and 1·2 mm. thick were tested at 17,000 volts, and made up into ten condenser sections of fifty sheets each. The sections are contained in a box of paraffined wood immersed in paraffin oil; they are connected up in two series, each having a capacity of ½ mf., and capable of withstanding 5,000 volts as a working pressure. These can be connected in parallel or in series, giving 1 mf. for 5,000, or ¼ mf. for 10,000 volts. Each section was tested at 9,000 volts for three hours. The rise of temperature as measured by a thermocouple after ten hours at a pressure of 5,000 volts was, at the centre of the sheets, 1·4° C.; at the edge 3·2° C. Measurements by the three-voltmeter method showed a loss of 100 watts in the condenser at 50 ∿.

The author gives examples showing the saving of energy not only in the line but also in the generator, when a condenser is used to increase the power-factor in a power transmission plant [see also Abstract No. 306 (1900)].

G. H. B.

228. *Graphical Determination of Regulating Resistances.* **E. Hunke.** (Elektrotechn. Zeitschr. 21. pp. 801–805, Sept. 27, 1900.)—The author develops a number of graphical methods for determining the consecutive sections of a regulating resistance required to fulfil given conditions. The first part of the paper deals with regulating resistances which are inserted into the main circuit, while the second part is devoted to the resistances used in the shunt circuits of dynamos or motors. In the case of the latter problem the open circuit and external characteristics of the machine must be known, and by making use of these curves the problem may be readily solved by the graphical method explained by the author. A H.

229. *Feeder Regulators.* **E. Stadelmann.** (Elektrotechn. Zeitschr. 21. pp. 285–288, April 12, 1900.)—The author considers the problem of designing a feeder-regulating resistance so that the fall of potential along the feeder and this resistance may be kept approximately constant within given limits, the maximum and minimum values of the feeder current being known. Curves are given for finding the number of contacts which must be provided for given ratios of the maximum to the minimum current, and for various values of the permissible variation in the drop along the feeder and regulating resistance.
A. H.

230. *Automatic Alternating-Current Brakes.* **J. Fischer-Hinnen.** (Elektrotechn. Zeitschr. 21. pp. 767–770, Sept. 13, 1900.)—The great advantage of automatic electromagnetic devices for applying the brake in the case of cranes, lifts, &c., consists in the fact that the brake is applied or lifted at the precise instant required, viz., when the current is switched off or on. In most of the automatic devices hitherto used a solenoid is employed for lifting the brake off the pulley. The dimensions of this form of apparatus cannot, however, be easily calculated. The author describes a form designed by himself and used by Krizik, of Prague, which is intended for alternating currents, and consists of a fixed and a movable core, resembling the stator and rotor of an induction motor. The two cores are provided with suitable windings, the windings of the fixed core being connected in series with those of the movable one. The range of the angular movement is about 90°. In the normal or "on" position of the brake, with no current through the automatic device, the relative position of the two cores is such that a current sent through them would produce fields at 90° to each other. In the application of this device to an ordinary band-brake a crank keyed to the shaft of the movable core releases or applies the brake according to the direction in which the core is moved round. The author works out the theory and deduces formulæ for this type of apparatus. **A. Kolben** (Elektrotechn. Zeitschr. 21. p. 854, Oct. 11, 1900) compares the performance of this brake with that of a solenoidal one, the result of the comparison being to show that the solenoidal brake is much the lighter, simpler, and cheaper of the two. A. H.

231. *Aluminium as an Electrical Conductor.* **J. B. C. Kershaw.** (Electrician, 45. pp. 669–671, Aug. 24, and 741–743, Sept. 7, 1900.)—The author draws attention to the vigorous manner in which the Pittsburg Reduction Company have pushed the use of aluminium for electric conductors since 1897, and have supplied large quantities at the low price of 1s. 2¼d. per pound. On this side of the Atlantic no large installation of electrical power exists in which aluminium has supplanted the use of copper. In the United States, however, transmission lines varying from 20 to 40 miles in length have been erected, carrying 1,000 to 5,000 h.p. at 10,000 to 20,000 volts. The author considers the question of the relative values of copper and aluminium for electric conductors to be one upon which it is at present impossible to express a definite opinion, and states that in the article to which this Abstract refers he has gathered together all the recently published facts and figures relating to the use of aluminium as an electrical conductor, and has supplemented these figures in some cases with figures of his own.

The relative conductivity of 99·6 per cent. aluminium, taking copper at 100, is 61·5 according to Northrup, and 60·5 according to Kelvin. For practical purposes these figures are useless, as aluminium is always alloyed with copper or iron to increase its strength. This causes a considerable reduction in the conductivity as follows :—

Aluminium with 0·50 per cent. copper	58·16
„ „ 0·75 „ „	56·87

The author's figures for the conductivity of aluminium wire supplied to him for experimental purposes by firms in this country are (copper = 100)—

No. 1 wire	Al. 51
No. 2 wire	Al. 54

Attention is drawn to the great variation in the strength (tensile) of aluminium according to the amount of alloy present and the extent to which it has been annealed.

From samples of aluminium wire supplied to the author he has obtained the following results :—

No. 1, 99 per cent. aluminium,	tensile strength	32,480	lbs. per square inch.
No. 2, alloy with 1 per cent. iron	„ „	38,080	„ „
No. 3, composition not stated	„ „	34,600	„ „

The breaking-strains fixed by the authorities for overhead electric wires in different countries are—

United Kingdom	31,360	lbs. per square inch.
United States	32,000	„ „
France	31,218	„ „

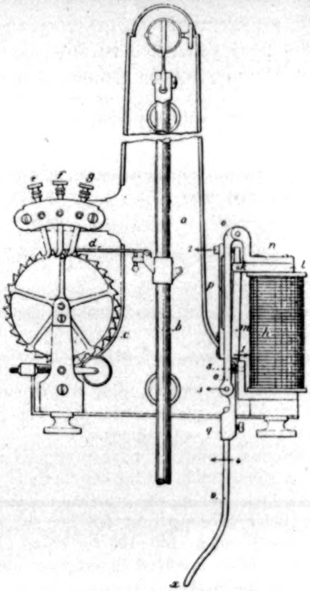
Aluminium wire should therefore be alloyed with enough copper to give it a tensile strength of 32,000 lbs. per square inch. This has been attained on the Stockholm line with 0·30 per cent. copper.

The Pittsburg Reduction Company have produced a wire with a tensile strength of 65,000 lbs. per square inch, but the conductivity was only 50 per cent. of that of electrolytic copper. Taking the practical conductivity of aluminium wire at 59·9 and the price of copper at 9d. per lb., the relative cost of aluminium to copper works out as 100 : 123 for equal capacity. It is quite probable that the extra trouble involved in erecting aluminium wires may diminish this saving in the material.

The author gives a table of the more important transmission schemes in which aluminium has been used. In spite of this considerable use it seems to be a most doubtful point whether or not aluminium possesses all the characteristics of a suitable metal for overhead work. E. C. S.

232. *Electric Driving of Looms.* (Génie Civil, 37. pp. 400–401, Sept. 29, 1900.)—This is a description of the gearing employed with an induction motor. In order to change the speed to suit the work in hand the motor pulley is altered when driving by belt, while if toothed gearing is used the pinion is changed, the distance between centres being suitably adjusted by a simple eccentric device. Both arrangements are illustrated. A. H. A.

233. *Campiche electrically-maintained Pendulum.* **G. Dary.** (Électricien, 20. pp. 179–180, Sept. 22, 1900.)—This pendulum is of the kind in which a small weight or a spring is displaced at each closure of the circuit and then released, this weight or spring acting on an arm fixed to the pendulum and imparting energy thereto. On the frame *a* are fixed the three principal parts of the apparatus, viz., the wheelwork *c*, the pendulum *b*, and electromagnetic device *h x*. The pendulum *b*, which beats seconds, is provided with a strip of steel *d* terminated by an anchor, and capable of being adjusted by means of a slide and an adjusting screw. At each oscillation of the pendulum towards the wheel *c*, this strip causes the wheel to turn through an angle corresponding to one tooth, and as the wheel has sixty teeth, it makes one revolution in a minute. The wheel *c* also bears at the end of one of its arms a small platinum pin which, once each revolution, touches two platinum contacts *g* during 0·8 second, and thereby completes a circuit, including a source of electrical energy and the electromagnet *h*. A small balanced wheel acts on the lower part of the wheel *c*, and serves as a jumper. The other contacts *e* and *f* can be used for controlling secondary clocks. The electromagnet *h* attracts and oscillates its armature *m*, and through the links *o q* the flexible strip *v x* which acts on the pendulum *b* and imparts energy thereto during 0·8 second, the flexible strip being immediately returned to its original position by an adjustable spring *p*. C. K. F.



234. *Industrial Electromagnets.* **A. Guénée.** (Ind. Élect. 9. pp. 427–429, Oct. 10, 1900.)—An electromagnet is considered when the armature is in movement as a motor, and the rule is deduced that "when the armature moves with constant speed and produces a *constant variation of flux* the pull is of constant value." Based on this reasoning a magnet has been designed of the ironclad type shown in the figure (Fig. 1). Inside is the movable armature N, the upper portion EE′ DD′ being made of discs of iron; the number and the distance between each of these may be regulated as desired. All types of armatures have been studied, and experiments have been made with different combinations of alloys to give various reluctances, but the form figured is the one which in general has proved most practicable. Experiments have been made with a registering dynamometer, which has indicated the effort at different parts of the armature path. With the same current strength and the same magnet the curves shown in Fig. 2 were obtained by regulating the distances between the discs (the abscissæ represent travel of the core in cm.). The most powerful magnet constructed gives a constant effort of 650 kilos with a length of path of 22 cm., and required 30 amperes at 220 volts, the weight of the magnet and armature being 207 kilos. These magnets were exhibited at the Paris Exhibition. W. W. H. G.

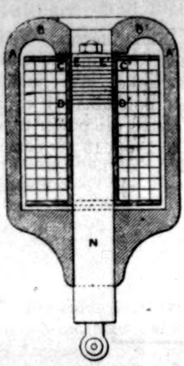


Fig. 1

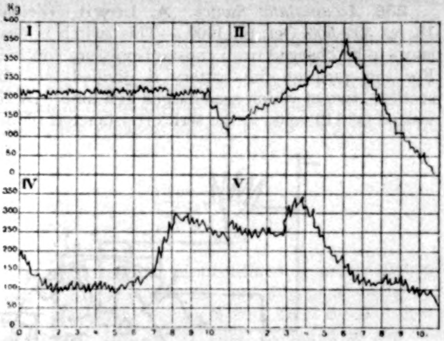


Fig. 2

235. *Calculation of the Diameter of Wire for Coils.* **A. Löwit.** (Elektrotechn. Zeitschr. 21. p. 881, Oct. 25, 1900; Elect. Engin. 26. p. 787, Nov. 23, 1900.)—The formulæ given correspond with the following, which are readily deduced:—

$$d = 1{\cdot}13\sqrt{\frac{\text{A.T.}\,\rho\lambda}{\text{E}}},$$

where d = diameter of wire in mm., A.T. = number of ampere-turns, ρ = resistance in ohms of a wire of length of 1 metre, having 1 sq. mm. sectional area, λ = mean length of a turn in metres.

For round spools this becomes—

$$d = 2\sqrt{\frac{\text{A.T.}\,\rho\text{D}}{\text{E}}},$$

where D = diameter of the mean turn.

This becomes for copper wire at 0° C.—

$$d = 0{\cdot}258\sqrt{\frac{\text{A.T. D}}{\text{E}}}$$

Using the current density, and taking account of the thickness of the insulating covering, we have (Uppenborn)—

$$(d + \delta) = \sqrt{\frac{\Delta\pi\text{D}lh\rho}{\text{E}}},$$

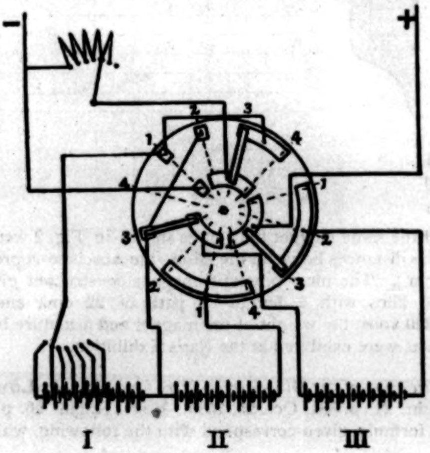
where δ = the double thickness of cotton, &c., Δ = current density in amperes per mm.^{2}, l = length of the winding space in mm., h = height of the winding space in mm.

This becomes for copper and round spools—

$$\Delta = 19{\cdot}2\,\frac{(d+\delta)^2 E}{D\,l\,h}.$$

W. W. H. G.

236. *Accumulator Switch.* **A. Lŏwit.** (Zeitschr. Elektrotechn., Wien, 18. pp. 505–506, Oct. 14, 1900.)—This switch is designed to permit accumulators to be charged from constant-pressure continuous-current street mains. For this purpose the battery is divided into three approximately equal sections, two of which are charged at a time. By this means the power to be wasted (at 110 volts) in the series resistance is reduced to about 13 per cent.



The switch, when in position 2 (see Fig.), permits Sections II. and III. to be charged; in position 3, Sections I. and III.; and in position 4, Sections I. and II. When in position 1 the switch permits the three sections to be discharged in series.

(The dotted lines in the Figure only indicate positions, not connections.)

C. K. F.

REFERENCES.

237. *Pollak Accumulators.* **J. Reyval.** (Écl. Électr. 24. pp. 441–445, Sept. 22, 1900.)—Particulars are given of the construction and mounting of the low discharge, high discharge, and traction type electrodes, together with useful data and curves relating to their electrical capabilities.

E. J. W.

238. *Automatic Circuit Breaker.* **H. Müller.** (Elektrotechn. Zeitschr. 21. pp. 805 807, Sept. 27, 1900.)—A Schuckert circuit breaker is described which breaks when the current exceeds a certain limit, and if closed by hand will again automatically break if the current be excessive. The action of the apparatus is clearly illustrated by a diagram.

E.K. S.

GENERATORS, MOTORS, AND TRANSFORMERS.

239. *Apparent Increase of the Air-gap due to Slotted Armatures.* **C. F. Guilbert.** (Ind. Élect. 9. pp. 377–379, Sept. 10, 1900.)—The author takes points on the polar face opposite the middle points of two consecutive slots, joins these points to the edges of the tooth between them, and produces these lines to meet at a point inside the tooth. He then makes the supposition that if we draw lines from this point through the air-gap these lines will be the direction of the lines of force. If l be the distance between the two points on the polar face, l' the breadth of the tooth, and δ the mechanical clearance, then on the above supposition the apparent air-gap δ' will be given by the equation—

$$\delta' = \frac{l}{2} \frac{\log \frac{l}{l'}}{\log \left\{ \frac{l-l'}{2\delta} + \sqrt{1 + \left(\frac{l-l'}{2\delta}\right)^2} \right\}}$$

For example, if the mechanical clearance of a continuous-current dynamo be 0·5 cm. and the breadth of a slot equals the breadth of a tooth, and if l' equals 1 cm., so that l practically equals 2 cm., then by the above formula $\delta' = 0{\cdot}785$. The formula can be at once extended to the case of alternating current motors where both the stator and rotor have slots. A numerical example for this case is worked out. A. R.

240. *Lanhoffer Dynamo.* **E. J. Brunswick** and **M. Aliamet.** (Électricien, 20. pp. 198–205, Sept. 29, 1900. Translated and commented on in the Elect. Engin. 26. pp. 512–515, Oct. 12, 1900.)—If we increase the excitation of a direct-current dynamo we can increase the voltage, but the practical limit to this increase is soon reached owing to magnetic saturation. On the other hand, if we diminish the excitation, keeping the current in the armature constant, there will soon be excessive sparking at the brushes. For example, an ordinary dynamo designed to give a voltage of 120 at a certain current can usually work fairly well when giving 100 or 150 volts. at this current. We may therefore say that it has a voltage coefficient of 1·5. The dynamo designed by E. Lanhoffer has a voltage coefficient of about 5. One of the uses of such a dynamo is to charge the accumulators carried by railway carriages. The trains may be of different lengths, hence the voltages required for charging are very variable. In the Lanhoffer dynamo there are two distinct magnetic circuits. The excitation of one of these fields is kept practically constant and if acting alone would produce at the terminals of the armature a voltage E. The excitation of the other field can be varied, and it produces a voltage which lies between the values $+e$ or $-e$, so that the voltage of the machine can be varied between $\mathrm{E}+e$ and $\mathrm{E}-e$. The regulation of the excitation is effected by a rheostat and reversing key. It is known how to construct dynamos so that they work fairly well at all loads without moving the brushes. The authors state that these principles are made use of in the construction of this dynamo. By a slight modification it can be turned into a motor-generator, and plans and full details are given of Lanhoffer machines of this type. They are in fact continuous-current transformers having a variable ratio. A. R.

241. *Construction of Dynamos.* **M. Leblanc.** (Electrician, 45. pp. 930–933, Oct. 12, 1900. Paper read before the International Electrical Congress at Paris.)—In every dynamo the useful fields are those which are interlinked with both the inducing and induced circuits. All other magnetic fields have a detrimental action, and hence it is desirable to reduce the leakage fields to a minimum by bringing the two circuits as close together as possible. This, in the author's opinion, can be best done by employing the same design for dynamos whether for direct or alternating current as is already used for machines of the induction type. One of the circuits will be wound in notches, cut in the internal surface of a ring, in the direction of the axis, and the other in similar notches on the external surface of a similar laminated ring concentric with the first and separated from it by a minute air-gap. The difficulty in making a direct-current machine of this type is that the magnetising force developed by the currents in the induced circuits is of the same order, so far as strength is concerned, as that developed by the inducing circuit, and hence, if constant voltage is to be maintained, the exciting current will have to be varied very considerably. To get over this difficulty the author winds a circuit on the field magnets, which is an exact reproduction of that on the armature and is in series with it, and hence the armature reaction is annulled. The absence of armature reaction would make it possible to increase the depth of the slots and so reduce the air-gap to the minimum required for mechanical clearance. The brushes of these machines would require no shifting and the weight of copper on the armature and field magnets would be practically the same. It would be possible to vary the voltages of these machines between the most extreme limits, as there would be no appreciable sparking.

The author then describes the principle of the compensating exciter which was exhibited by the Grammont firm at the Paris Exhibition [see Abstract No. 2100 (1900)]. A graphical proof is given of the method adopted of compounding an alternator for constant voltage; when the inductances of the machine are constant the proof is rigorous. In conclusion the author lays great stress on the advantages to be gained by adopting the induction type of machine as the standard. He has shown that it is perfectly easy to obtain automatic regulation of the exciting current. He considers that the Grammont alternator and compensating exciter demonstrate—(1) the automatic excitation of this type of machine; (2) that it gives a constant voltage at all loads and power factors; (3) that the brushes of the exciter wear exceedingly well; (4) that machines of this type run perfectly in parallel with machines of other types. A. R.

242. *Tendency of Modern Dynamo Design.* **W. Cramp.** (Elect. Engin. 26. pp. 475–477, Oct. 5, 1900.)—Conclusions are drawn from the machines shown at the Paris Exhibition as to the types of field magnets, armatures, &c., that are becoming the standards. Figures are quoted to show the close agreement in overall dimensions of machines by various makers. The standard field frame is the circular shape with inwardly projecting radial poles. The material for the field is almost always cast steel, which gives the machines a very light and neat appearance, when contrasted with those made with cast-iron frames. Drum armatures were nearly universal and slotted stampings were nearly always used for the core. The armatures of all the alternators shown contained iron. The alternators were all of the flywheel type, and in nearly every case the field revolved. Alternators in which the revolving field magnets projected radially inwards from the extended fly-

wheel rim were much in evidence. Laminated pole-faces were not uncommon and some small machines had their field magnets laminated throughout.
A. R.

243. *Design of Large Tramway Generators.* **H. F. Parshall.** (Street Rly. Journ. 16. pp. 775–778, Oct., 1900.)—The author starts by assuming an efficiency of 94 per cent., the losses being allocated as follows:—

C^2R loss in armature.....................	2·25 per cent.
Core loss in armature	2·25 „
Field-magnet loss	0·75 „
Commutator loss C^2R and friction	0·75 „

The rise of temperature per watt per square inch at the periphery of an armature, should be 10° to 15° C. at 2,500 feet per minute, if measured by a thermometer, or 15° to 22° if measured by increase of resistance. In the field magnets the rise of temperature per watt per square inch should be about 60° by thermometer, or 120° by resistance, in the commutator about 15°. If the rise of temperature of any part is limited to 30° by thermometer, or 45° by resistance, the radiating surface per kw. output should be for the field 15 square inches, for the armature 18·75 square inches, and for the commutator 3·75 square inches. In calculating core loss, distortion, which may increase the maximum density 30 per cent., must not be lost sight of. The densities should be taken so that the average armature core loss is less than 1 watt per lb. A curve is given showing watts per lb. at 7·5 cycles per second for different densities. With carbon brushes the current density should not exceed 40 amperes per square inch. The contact resistance may be 0·03 ohm per square inch, or 1·2 volts drop from contact resistance. The pressure of contact may be 1·5 lbs. per square inch, in which case, at 2,000 feet per minute, the mechanical friction is about 50 per cent. of the C^2R loss. The effect of resistance of brushes, self-induction of armature coils and frequency of reversal is discussed. Particulars are given of a General Electric Company's 550-kw. generator which has proved very satisfactory.
R. B. R.

244. *Construction of Large Dynamos as Exemplified at the Paris Exhibition.* **S. P. Thompson.** (Elect. Engin. 26. pp. 374–375; Discussion, p. 375, Sept. 14, 1900. Abstract of a paper read before the British Association.)—The two-pole type of machine so largely used in England was not exhibited by any Continental firm except for very small motors. The copper type of alternator with the armature built up of thin coils of bare copper was not represented. The alternators exhibited might be divided into four types—(1) Fixed external magnets and a revolving armature inside same (only a few exhibited). (2) Stationary armature surrounding an internal system of magnet poles built up on a flywheel (large number exhibited). (3) Inductor type with no revolving conductors in either armature or field (very few exhibited). (4) Stationary armature inside a revolving field-magnet system, the poles being bolted to the inner periphery of the flywheel rim (three machines exhibited). The fourth type is similar to some alternators made by C. E. L. Brown, for Cairo, with the poles fixed inside the rim; the revolving mass of each pole tends to keep it in place and counteracts the magnetic pull. The Ferranti method of winding bare copper strip in an edgewise spiral for the exciting coil of field magnets is very largely used. The greater number of the alternators had two slots per pole per phase; one large machine had only one slot; the A. E. G. alternator (the largest in the Exhibition) had five slots, and there was one machine with 2¼ slots per pole per phase. With the increase in diameter of alternators the mechanical stability of the large rings is of importance. In one case the cast-iron frame was about 1 yard wide, whereas the length of the core was only 10 inches. In one of the Schuckert alternators the required stiffness was obtained by a number of stay rods secured to a ring of comparatively small diameter concentric to the shaft. Methods of compounding alternators are referred to, and also an unsymmetrical system of winding on a three-phase Ganz alternator.

The Russian branch of Siemens and Halske exhibited a direct-current dynamo in which the tendency to spark was kept down by arranging the inner surfaces of the poles so that they do not form a cylindrical surface concentric with that of the armature. The air-gap was smallest at the edge of the pole to which the armature conductors approached and largest at the edge from which they receded. In a Ganz direct-current dynamo unusually large teeth were found in the armature, there being only six teeth per pole. The poles had extended pole-pieces of laminated steel, some of the plates having the polar extensions cut off, so that the horns had a small cross-section of iron.

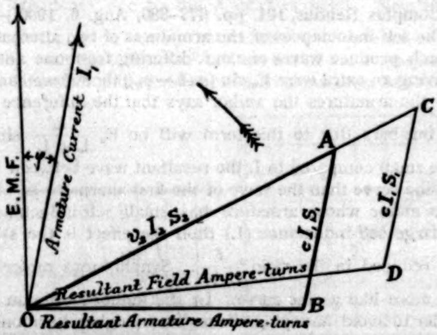
The Steinmetz formula (the diameter of the armature core multiplied by the length of the core, both in inches, divided by the output in kilowatts) gave a figure varying from 6, in bad designs, down to as low as 1¼ for a well-designed 1,000-h.p. machine. E. K. S.

245. *Regulating Resistances for Shunt-wound Dynamos.* **E. Dick.** (Zeitschr. Elektrotechn., Wien, 18. pp. 489–493, Oct. 7. 1900.)—The author deals with the following problem : Given the open-circuit characteristic of a shunt-wound machine, to design a regulating resistance such that as the load varies the p.d. across the dynamo terminals may be kept within given limits by altering the resistance. Before attacking this problem it becomes necessary to determine the total e.m.f. corresponding to a given p.d. and armature current. The author does this for a machine in which the brushes have no lead, and then shows how the consecutive sections of the regulating resistance may be found by a graphical method. He then extends the result to a machine in which the brushes are given a forward lead. A. H.

246. *Experiments with a Motor Generator.* **W. E. Parker** and **F. W. Grover.** (Amer. Electn. 12. pp. 427–430, Sept., 1900.)—This is an account of some experiments with a motor generator for direct and alternating current. The alternator armature is fixed, built up of discs slotted inside. The field revolves inside the armature and consists of two five-pointed star-shaped castings mounted on the shaft, facing each other, with their arms interlaced, giving a ten-pole field with one exciting coil. The machine when tested did not give the expected result. The induction in various parts of the magnetic circuit of the direct-current motor was tested, and showed that only 55·55 per cent. of the induction in the field coils passed through the armature. A considerable part of the leakage went through the alternating armature. The induction in the alternating armature was tested, showing considerable variation in the different coils. Curves are given for the e.m.f. of different armature coils, showing considerable variation, not only between different coils, but also between successive undulations on the curve for one coil. This is explained by variations in the shape of the pole-pieces, and in the air-gap between a given armature coil and different pole-pieces.

R. B. R

247. *Theory of Alternators and Synchronous Motors.* **E. E. Seefehlner.** (Zeitschr. Elektrotechn., Wien, 18. pp. 454–461, Sept. 16; 465–471, Sept. 23; and 514–518, Oct. 21, 1900.)—An important and suggestive contribution to the theory of alternators. The author points out the advantages which have resulted from considering the induction motor as a special case of the general alternating-current transformer, and develops a theory of the synchronous motor and alternator by regarding it as a particular case of the induction motor. According to this view an alternator is an induction motor which runs synchronously. The alternator armature is regarded as the primary or inducing circuit, and the field coils as the secondary or induced circuit. Since the slip is zero, the frequency of the induced currents is also zero—the current is, in fact, a continuous one, supplied by an independent source. The Heyland diagram for induction motors may therefore be applied to alternators, and by means of it many of the peculiarities in the behaviour of an alternator may be readily accounted for. The author next criticises the ordinary methods of dealing with armature reaction, and points out the wide discrepancies which are in most cases found to exist between the results of experiment and deductions based on theory. He then states that such discrepancies very largely disappear if instead of dealing with magnetic fields we consider *ampere-turns.* The effective e.m.f. is regarded as due to the resultant armature ampere-turns. In the Figure let OC denote the exciting or field ampere-turns I_2S_2. On account of magnetic leakage only a certain fraction, $OA = v_2I_2S_2$, of the field ampere-turns will be effective in producing a flux through the armature. If with these "transferred" ampere-turns we compound vectorially the armature ampere-turns $AB = cI_1S_1$ (where I_1 = R.M.S. current and c is a coefficient depending on the number of phases and the wave-shape), we obtain the resultant or effective ampere-turns OB, the e.m.f. being in quadrature with OB. The author points out that the widely used method in which the mean arithmetical value of the armature current is considered in dealing with armature reaction is incorrect. The alternating armature ampere-turns may be analysed into two components, consisting of oppositely *rotating* ampere-turns of half the amplitude. It is then evident that the correct value of the current to be considered is half its maximum value. Accordingly, $c = qS_1\frac{I_1}{2k}$, where q = number of phases, I_1 and S_1 = R.M.S. current and turns per phase respectively, and k = amplitude factor of wave (R.M.S. value ÷ maximum value). The value



of v_2 may be found from the short-circuit characteristic, and so long as this characteristic is a straight line the value of v_2 is constant. When the armature is short-circuited its resultant ampere-turns become vanishingly small, hence (see Fig.) $v_2 I_2 S_2 = c I_1 S_1$, and v_2 may be found. The author lays particular stress on the fact that v_2 will have different values for machines of the same type but with different numbers of poles, and that the value of v_2 for a polyphaser will depend on the number of phases in use. Assuming that the open-circuit and short-circuit characteristics of the alternator and the wave-shape[1] are known, we may, by the aid of the simple vector diagram shown in the figure, solve all important problems concerning alternators and synchronous motors. The author has tested the practical value of his theory by applying it to two widely different types of alternator, and the calculated results show remarkable agreement with the experimental ones, the divergence between the two being in most cases within 3 per cent. None of the methods hitherto in use have given such good results. A. H.

248. *Effect of Parallel Running of Alternators on the Shape of E.M.F. Waves.* **A. Pérot.** (Comptes Rendus, 131. pp. 377–380, Aug. 6, 1900.)—Suppose L and L^1 to be the self-inductances of the armatures of two alternators running in parallel which produce waves of e.m.f. differing from one another merely by the first having an extra term $E_n \sin(n\omega t - \phi_n)$, then if we can neglect the resistances of the armatures the author says that the difference of potential between the bus-bars due to this term will be $E_n \frac{L'}{L + L'} \sin(n\omega t - \phi_n)$. Hence if L' be small compared to L the resultant wave between the bus-bars is nearer to a sine curve than the wave of the first alternator is. If we couple a synchronous motor whose armature has small self-inductance (l) to an alternator of large self-inductance (L) then the effect is the same, the harmonics being reduced in the ratio $\frac{l}{L + l}$. Synchronous motors thus make the p.d. wave more like a sine curve. In the author's opinion it would be prudent in order to avoid annoying effects from higher harmonics never to put an alternator on to the bus-bars or take one off without the protection of a synchronous motor in the central station. The effect on the wave form of putting an alternator of small self-inductance in parallel with one of large self-inductance is very striking. In an experiment the ratio of the maximum e.m.f. of an alternator to its effective e.m.f. was 1·65; when a small alternator was put in parallel with it, the ratio of the maximum p.d. at the terminals to the effective p.d. was reduced to 1·436. In a sine curve this ratio is 1·414. A. R.

249. *Eliminating the Harmonics from E.M.F. Waves.* **G. Claude.** (Comptes Rendus, 131. pp. 613–615, Oct. 15, 1900.)—One way of doing this is to use synchronous motors having feeble self-inductances, as suggested by Pérot [see preceding Abstract]. This risks bringing in new harmonics. The author suggests putting in an inductive coil and a capacity in series between the terminals of the alternator, the capacity being chosen so that resonance takes place at the frequency of the harmonic it is desired to suppress. This resonant circuit will have practically no effect on the fundamental of the e.m.f. wave. The author experimented on an alternating network in Paris with unsatisfactory results owing to the constant breaking down of the condensers. This, he thinks, can be got over by using Lombardi's condensers. Getting rid of the harmonics from e.m.f. waves diminishes the danger from condenser shocks from the mains. The author previously proposed (Comptes Rendus, Nov. 20, 1898, p. 689) to get rid of the earth capacity of the mains by means of inductive coils. It would be advisable to make the networks as safe as possible, seeing that the number of fatal accidents is increasing every year.

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[1] The author finds that, in spite of considerable changes in the wave-shape with the nature of the load, the amplitude factor k does not change much in a given type of machine.

A. R.

250. *E.M.F. of Alternators on Open Circuit.* **C. C. Hawkins.** (Elect. Rev. 47. pp. 655–656, Oct. 26; 691–694, Nov. 2; and 857–860, Nov. 30, 1900.)—In predetermining the e.m.f. which an alternator will give when run at a certain speed, it is customary to use the equation—

$$E = K \cdot 2Z_a \times \frac{pN}{60} \times \text{No. of inductors in series} \times 10^{-8} \text{ volts,}$$

where Z_a is the total number of lines entering the armature from one pole, and $\frac{pN}{60}$ is the frequency due to the p pairs of poles. Now the factor K depends on the "form factor," *i.e.*, the ratio of the effective e.m.f. to the average e.m.f., and on the "width coefficient," or the ratio of the average e.m.f. to the gross average e.m.f., when differential action is supposed to be absent. In the calculation of K it is usually assumed that the flux from one pole face is confined to the width of the pole face. In this paper the fringe of lines, which must necessarily surround the actual pole face, is taken into account. To get these lines the method used by F. W. Carter [Abstract No. 2101 (1900)] is employed.

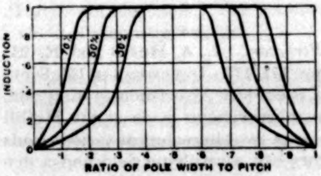

FIG. 1.—FLUX-DISTRIBUTION ALONG PITCH-LINE.

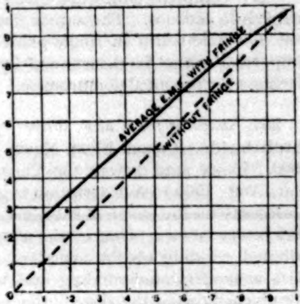

FIG. 2.—AVERAGE E.M.F.

The three curves in Fig. 1 illustrate the flux distribution when the air-gap is one-twentieth of the pitch, and the pole width is 0·7, 0·5, and 0·3 of the pitch respectively.

In Fig. 2 the dotted line is the curve giving the average e.m.f. neglecting the fringe, and the full line when it is taken into account. The case of an alternator with slotted armature is next considered, and tables and diagrams are given for the net average e.m.f., the effective e.m.f., the form factor, and K for one, two, three, and four slots per pole respectively, these slots being equally spaced over the pitch.

When there are several slots per pole the curves showing how the ratio of the maximum to the effective e.m.f. varies have several maxima and minima values, corresponding to certain values of the ratio of the pole width to pitch. The effect of the fringe of lines is to smooth out the curves of this ratio, so that there are no abrupt changes of value. They show, however, that sometimes a very small difference in pole width produces a great difference in the value of the ratio.

The following values, suitable for three- and two-phase machines, illustrate the tables given :—

VALUE OF K WITHOUT FRINGE.

Two Slots per Pole and per Phase.	Ratio of Pole Width to Pitch.				
	0·1	0·3	0·5	0.7	0·9
One-sixth of pitch apart	2·235	1·55	1·29	1·12	0·983
One-fourth of pitch apart.........	2·235	1·393	1·225	1·08	0·93
VALUE OF K WITH FRINGE.					
One-sixth of pitch apart	1·315	1·238	1·13	1·05	0·966
One-fourth of pitch apart.........	1·24	1·193	1·102	1·02	0·915

Very complete tables are given for a smooth-core armature, taking the fringe into account. The author discusses the question of the best values for coil and pole width in single-phase alternators, and concludes that the best proportion cannot be determined by any mathematical law, but must remain a matter for practical compromise. A. R.

251. *Shape of the E.M.F. Waves of Alternators.* **L. A. Herdt** and **E. M. Archibald.** (Canad. Elect. News, 10. pp. 171–173; Discussion, p. 156, Sept., 1900. Paper read before the Canadian Electrical Association at Kingston, Ont., Aug., 1900.)—A description is given of experiments made at the McGill University on the shape of the e.m.f. waves of two alternators at various loads and power factors. One of the alternators had a revolving field and a distributed winding on the armature, and the other was an inductor dynamo with a concentrated winding and badly designed inductor lugs. Diagrams are given showing the distribution of the lines of force over the pole faces, the shape of the e.m.f. waves at no load and with lagging currents at various outputs, &c.

At full load and unity power factor the e.m.f. is moved about 10 degrees from that at no load in the direction of rotation. As the power factor is decreased, the current lagging, this displacement is reduced until with a power factor of 0·55 the e.m.f. wave is nearly back to its original position at no load. The change of shape of the e.m.f. wave of the inductor machine as the power factor is varied is very much more pronounced. There is but little resemblance between the shape of the waves when the power factor is unity and when it is 0·95. Several synchronous motors were in turn operated from a generator whose wave form was varied by changing the character of the auxiliary load. In every case dissimilarity of wave increased the idle current and also the energy absorbed. The tendency to fall out of step on slight provocation was very marked with dissimilar waves. The authors state that they undertook the experiments to see whether it was possible to introduce a clause relating to wave forms into alternator specifications. They are still experimenting on the subject, and this paper is only preliminary.

Discussion.—**A. A. Dion** stated that to those engineers who were accustomed to look upon the sine curve as approximately correct in alternating current calculations the results obtained were somewhat startling. **P. G. Gossler** said that frequently the demagnetising effect distorted the magnetic field so as to throw the maximum e.m.f. further than 15 degrees one way or the other. He regarded the small distortion as an individual characteristic of the machine. In his opinion the curves showed that the machine was a very good one. **L. A. Herdt** in his reply said that the machine was a very good one. A. R.

252. *Distribution of Magnetic Flux in Alternators.* **C. Westphal.** (Elektrotechn. Zeitschr. 21. pp. 878–881, Oct. 25, 1900.)—The author applies the method previously used by him in connection with continuous-current dynamos [see Reference No. 2324 (1900)] to alternators, and gives diagrams showing approximately the distribution of the induction round the periphery of the alternator field magnet due to the field excitation. By an integration of these curves the instantaneous values of the impressed flux traversing the armature coils are obtained. The author next establishes an equation connecting the total actual flux through the armature coils with the number of turns in the exciting and armature coils, and the instantaneous values of the exciting and armature currents. The equation is next simplified by supposing that the armature has a smooth core, and this simplified equation is used for plotting the armature current-wave by a step-by-step process of graphical integration. The results obtained show that the frequently made assumption of a constant armature inductance is—even in the case of smooth-core armatures—not justifiable. The concluding section of the paper deals with the effect of magnetic leakage. A. H.

253. *Power Factor in Central Station Work.* **F. H. Leonard, Jr.** (Canad. Elect. News, 10. pp. 173–175; Discussion, pp. 157–159 and 165–167, Sept., 1900. Paper read before the Canadian Electrical Association at Kingston, Ont., Aug., 1900.)—Diagrams of the e.m.f. and current waves of a transformer at no load and full load are given to illustrate that the closer the resemblance between the e.m.f. and current waves, and the nearer they approach one another, the higher will be the power factor. By increasing the field excitation of a synchronous motor we can introduce leading currents into a network which will help to counterbalance the lagging currents due to arc lamps and induction motors. This is sometimes a convenient way of overcoming line-drop and poor power factor. Synchronous motors, however, are only possible with steady loads. A single synchronous motor subject to sudden load variation defeats all attempts at good regulation of the system. The author is altogether in favour of induction motors as against synchronous motors. When alternating-current enclosed arc lamps with compensating coils are used the power factor of the circuit is low. Ordinary alternators are not suitable for loads with low power factors. The best modern alternators give an inherent regulation indicated by a short-circuit current of at least three or four times the full-load current; the change in the excitation at full load and 0·8 power factor is not more than 20 per cent.; they can stand an overload of 25 per cent. for six hours, and one of 50 per cent. for one hour, without overheating. These alternators are excellently adapted for motor work. A power factor considerably less than unity is now regarded as a necessary evil consequent on the opening up of a new and lucrative branch of the industry, and engineers would do well to take it into account in their calculations.

Discussion.—**L. A. Herdt** said he thought that with a proper adjustment of the field excitation of a synchronous motor the power factor might be made to approach very closely to unity. **F. H. Leonard** replied that theoretically this was possible, but in practice it was impossible, as when a synchronous motor is over-excited beyond a certain limit a flickering of the voltage over the whole circuit occurs. **P. G. Gossler** said that a power factor of unity could be obtained, but that in practice it corresponded to a very unstable condition of working. He regarded synchronous motors as almost indispensable adjuncts in central station working. In the arc-light system at Buffalo the power factor is kept at 0·97 or 0·98 by their means. He laid stress on the fact that in the operation of induction motors it is necessary to regulate the generator excitation in order to compensate for changes in the load on the motors. **H. R. Leyden** said that in his station he is changing over all the direct-current arc lamps into enclosed alternating-current lamps. Thirty of these lamps are run in series at a pressure of 2,400 volts. The power factor of the lamp circuit is 0·85. He concluded by stating that for large motors which will run on steady loads he would use synchronous motors, but for distributing power in a factory he would prefer to use induction motors. A. R.

254. *Induction Motors with Large Starting Torque.* **M. Déri.** (Ind. Élect. 9. pp. 425–427, Oct. 10, 1900.)—The principle underlying the construction of these motors has already been briefly explained [see Abstract No. 1285 (1898) and Abstract No. 2320 (1900)]. The present paper describes a number of methods suitable for use with single-phase induction motors. In Fig. 1 is shown a form of winding suitable for a single-phase motor whose stator windings may be coupled up so as to produce either a four-pole or a six-pole field. The necessary change of connections may be effected by means of a suitable switch. At starting a four-pole field is used, and it will be noticed that the rotor winding behaves like an ordinary Gramme winding in a four-pole field. When the motor has run up to speed the connections are changed so as to give rise to a six-pole field. In such a field each pair of diametrically opposite coils consists of two coils moving under pole-pieces of opposite polarity, and hence having e.m.f.'s induced in them which act in the same direction round the local circuit formed by the two coils; the resistances *r*

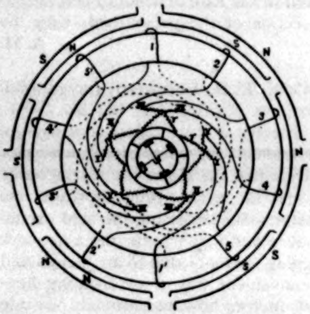

FIG. 1.

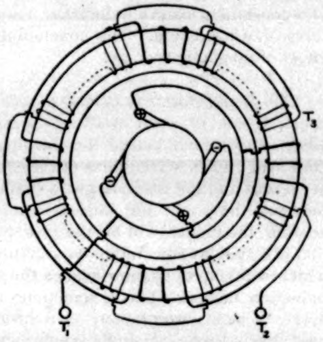

FIG. 2.

inserted between the junctions of opposite coils and the commutator segments now not conveying any current. The brushes may now be short-circuited and lifted off the commutator. The winding shown in Fig. 1 is equally applicable to a polyphase motor, in which case the brushes and commutator are entirely dispensed with, their place being taken by a simple continuous ring which connects all the junctions of the resistances *r*. The two numbers of poles may be chosen in a great variety of ways (*e.g.*, 4 and 6, 6 and 8, 8 and 12, &c.), the only restriction being that the greatest common factor of the two numbers should be an even sub-multiple of one number of poles, and an odd sub-multiple of the other number. Fig. 2 shows another arrangement which has been used. It may be described as a combination of an eight-pole induction motor with a four-pole series-wound motor, and instead of using first a four-pole and then an eight-pole field (as would have been the case with a motor of the type just described, Fig. 1), *both* fields are used simultaneously at starting. At the instant of switching on, the p.d. across the eight-pole stator winding (*i.e.*, between the points T_3 and T_2) will, on account of the low impedance of this winding, due to the presence of the short-circuited rotor winding, be very small, and the four-pole winding (thick lines) will receive a high p.d. As the motor runs up to speed, however, the p.d. across the eight-pole winding increases, while that across the four-pole one decreases. When the normal speed has been reached, the terminals T_1, T_3, are connected by a short-circuiting switch, and the brushes lifted off the commutator. The author states that motors of this type have been used in Vienna and Budapest and have given satisfaction. A. H.

255. *Measurement of Slip of Induction Motors.* **W. H. Browne, Jr.** (Elect. World and Engineer, 36. p. 574, Oct. 13, 1900.)—Two revolving contacts are fixed, one to the shaft of the generator, the other to that of the motor, and are arranged to break contact at one point of the revolution. These two are joined in parallel across a circuit consisting of a battery and a single-stroke bell arranged to ring when the armature is released. The bell will then ring only when the two contacts are broken simultaneously, which will occur at every complete revolution lost by the motor. G. H. B.

256. *Alternating-Current Motors.* **J. Buchi.** (Écl. Électr. 25. pp. 151–155, Oct. 27, 1900.)—The author points out the conditions which alternating-current motors should satisfy in order to meet the requirements of the consumer as well as the suppliers of electrical energy. The theory of the effect of inserting non-inductive resistances into the rotor circuits is discussed geometrically by a diagram attributed to Heyland. It is shown that the insertion of resistance into the rotor circuits not only increases the starting torque but also, for a motor of given output, diminishes the effective number of turns. The author also states that a high-starting torque is obtained by having the induction density in the iron high. W. G. R.

257. *Experiments with Rotary Converters.* **A. G. Grier** and **J. C. Hyde.** (Canad. Elect. News, 10. pp. 175–179, Sept., 1900. Paper read before the Canadian Electrical Association at Kingston, Ont., Aug., 1900.)—Diagrams are given of the e.m.f. waves at the terminals of a rotary converter at various loads. These curves illustrate that the effect of armature reactions on the wave form is hardly noticeable. The question of the compounding of rotaries to keep up the direct-current voltage when the load comes on is considered. Problems connected with the regulation of rotaries in street railway work are

solved both graphically and analytically. Experiments on inverted rotaries, *i.e.*, rotaries used to convert direct into alternating current, are also described. A lagging current load makes an inverted rotary speed up, whilst a leading current makes it slow down. Hence with lagging currents we need to strengthen the field if the rotary is to revolve uniformly. This could be done automatically by driving the exciter off the shaft of the rotary—a method devised and put in practice by B. G. Lamme [Abstract No. 1575 (1900)]. The iron of the exciter should be worked at a low induction. Inverted rotaries are now employed to transmit power from large direct-current power stations to great distances. If an inverted rotary were fitted with a compensating exciter similar to that devised by Rice, of the General Electric Company, then theoretically the frequency of the current would be constant.

A. R.

258. *Transformer Core Ageing Tests.* **W. E. Goldsborough.** (Elect. Rev. N.Y., 37. pp. 395–396, Oct. 17, 1900.)—Two series of tests were made on five modern 60-cycle 5-kw. transformers from different manufacturers. The transformers were kept at full load for 9½ hours a day five days in the week, and allowed to cool to a temperature of about 26° C. during the remaining 14½ hours. On the other two days the periods of full load and of rest were 5 hours and 19 hours. The leading results are given in the following table :—

Hours at Full Load.	Core Loss in Watts.				
	A	B	C	D	E
0	85	74	95	72	91
350	83	73	91	70	90
822	83	74	91	69	92
(Interval of Eight Months.)					
822	85	75	93	74	93
1,403	81	73	88	73	96
1,700	79	76	85	74	95

Transformers A, B, and D are oil-insulated. A and B are of the "core" type, C is of the "shell" type. The values given in the table were selected from among all the values obtained as being those which conform most nearly to the actual average performance of the transformers during the tests. Intermediate readings were obtained in the case of four of the transformers, which showed a temporary spasmodic departure from the mean values.

W. H. E.

259. *Constant Potential Continuous-Current Transformer.* **F. W. Davies.** (Elect. Rev. 47. pp. 614–615, Oct. 19, 1900.)—A method is described of constructing a continuous-current transformer so that it will give at all loads a constant potential difference at the secondary terminals. It is applicable only to transformers of the single-field type where both the primary and secondary windings are wound on one core. The field magnets are provided with slots in which a compensating coil in series with the secondary circuit is wound so that the magnetism of part of the pole face is strengthened as the load increases. The primary coil on the armature is wound with a pitch large enough to enclose the whole armature flux, but the secondary coil is chordwound and its pitch is only large enough to enclose the whole of the lines of force coming from the compensating coil. By this means it is possible to make the ratio of transformation either increase as the load increases, or remain approximately constant at all loads. Diagrams are given of the magnetic circuit and of the armature windings for a two-pole machine. A. R.

REFERENCES.

260. *Designs for Double Current Generators.* **J. C. Brocksmith.** (Amer. Electn. 12. pp. 134–138, March; pp. 186–188, April; and pp. 228–231, May, 1900.)—Particulars and drawings are given of 1, 2, and 4 kw. machines, which, when suitably connected, will give the following: Direct current generator or motor; single, two, or three-phase generator or motor; rotary converter changing single, two, or three-phase current to direct current, and *vice versâ;* phase transformer changing alternating current of one phase to that of any other phase. The windings give 110 volts direct current, 80 volts single or two-phase, and 70 volts three-phase, the periodicities being 60 or 125. E. K. S.

261. *Theory of Commutation.* **C. C. Hawkins.** (Electrician, 46. pp. 19–21, Oct. 26; and 44–46, Nov. 2, 1900; from a brochure published by the Electrician Printing and Publishing Company.)—This paper, which is based on the work of Arnold and Mie [Abstract No. 1084 (1899), is of a mathematical nature, and does not admit of a useful Abstract. A. H.

262. *Polyphase Railway Apparatus and Methods.* **L. Bell.** (Street Rly. Journ. 16. pp. 804–808, Oct., 1900.)—A description with illustrations is given of the development of the large direct-driven polyphase generator. Details are given of the stator of a 3,500-kw. direct-connected alternator for the Metropolitan Street Railway, New York [see Abstract No. 1372 (1900). The author points out that there are cases where the adoption of polyphase motors for tramway working would be very advantageous. A. R.

263. *Theory of Induction Motors.* **G. Ossanna.** (Elektrotechn. Zeitschr. 21. pp. 712–713, Aug. 23, 1900.)—A brief account of the author's graphical method of dealing with the problem of the induction motor. The method has already been referred to in Abstract No. 1781 (1899). A. H.

264. *Vector Diagram of Induction Motors.* **F. Emde.** (Elektrotechn. Zeitschr. 21. pp. 781–782, Sept. 13, 1900.)—The author critically examines the induction motor diagrams proposed by Heyland, Ossanna, and Kapp, and points out that so far as the secondary flux is concerned these methods all lead to different results. He then gives a construction of his own in which the difficulties connected with the other methods are got rid of. A. H.

265. *Diagram of General Alternating-Current Transformer.* **F. Emde.** (Elektrotechn. Zeitschr. 21. pp. 854–855, Oct. 11, 1900.)—A letter in which the author further discusses the vector diagram of the general alternating-current transformer, and replies to some criticisms passed on his previous letter, noticed in the preceding Abstract. A. H.

266. *Diagram of General Transformer.* **B. A. Behrend, K. Kuhlmann, J. Heubach,** and **F. Emde.** (Elektrotechn. Zeitschr. 21. pp. 875–876, Oct. 18; 894–895, Oct. 25; and 941–942, Nov. 8, 1900.)—Some further correspondence on the diagram of the general alternating-current transformer, and its relation to the induction motor diagrams of Behrend, Heyland, Blondel, and Ossanna. A. H.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

267. *Alternate-Current Working.* **H. S. Meyer.** (Elektrotechn. Zeitschr. 21. pp. 858–861, Oct. 18, 1900.)—This is a general review of the various systems having more especial reference to American as contrasted with Continental practice. The choice of frequency is discussed, and the usual arguments for and against high frequency are stated. As an example of low-frequency working the Brooklyn Edison Central Station is quoted. Here 1,500-kw. alternators are directly coupled to compound engines with a speed of 75 r.p.m. This gives with 40 poles 25 ∿, whereas if 60 ∿ had been required 96 poles would be necessary. On the other hand, so low a frequency as 25 is unsuitable for lighting, and a "frequency changer" must be used. The Figure (see Fig. 1) shows the arrangement. It consists of a six-pole induction motor A, the armature of which is rotated by a four-pole synchronous motor B. The supply at 6,600 volts 25 ∿ three-phase is transformed to 2,300 volts 62·5 ∿ two-phase. The normal speed of A is 500 r.p.m. of B 750 r.p.m. At the Chicago Edison Central Station 200-kw. 20-pole machines are used of the double-current type, enabling a direct current to be obtained from the low-frequency supply.

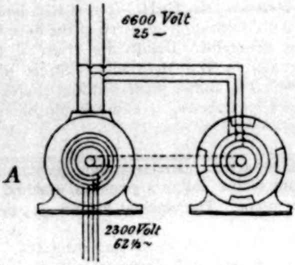

Fig. 1.

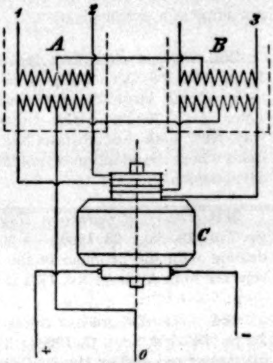

Fig 2

For electric furnaces, as in the manufacture of calcium carbide or carborundum, very low frequency values such as 10 to 20 may be used with advantage.

The "Monocyclic system" is described and discussed. This is essentially a single-phase system with a third or *teaser* wire for supplying power to motors. An explanation follows of the system invented by Scott. The use of six-phase currents is next discussed, and the arrangement of circuits for a six-phase transformer shown. Then follows an account of an interesting combination of systems which the author has seen at the Utah Power Company in Salt Lake City, where a two-phase rotary transformer, by the use of Scott's arrangement, is supplied from a three-phase circuit. The arrangement is shown in Fig. 2. A and B are two transformers, C the rotary. The middle points of the two-phase windings are connected to the neutral conductor of the network.

The typical properties of synchronous and asynchronous motors are finally fully considered. W. W. H. G.

268. *Electrical Supply.* **C. P. Steinmetz.** (Elect. World and Engineer, 36. pp. 486–487, Sept. 29, and 529–530, Oct. 6, 1900. Paper read before the Association of Edison Illuminating Companies, Saratoga, Sept. 4, 1900.)—The usual system in America is the continuous-current three-wire system, with direct-coupled units, or pairs of 125-volt face-commutator machines. This type is the most economical of space, but for 250-volt machines the carbon brush separate commutator type is generally employed. Outlying districts are supplied with alternating current by belted or, occasionally, by direct-connected alternators. In these stations the storage battery has been successfully introduced. It is now becoming the practice to generate the power in one large station outside the town, using three-phase direct-coupled machines; the power is transmitted at high pressure to substations, where it is transformed and converted into continuous current for the main distribution, alternating for outlying districts and pioneer work, and constant current for arc lighting.

As to frequency: incandescent lighting is feasible at 30 and satisfactory at 40 cycles; arc lighting is feasible at 40 and satisfactory at 60, though still better at 125; rotary converters are feasible at 60 cycles, but perfectly satisfactory only at 25 cycles. In direct-coupled slow-speed alternators the lowest frequency is the most desirable. Where an appreciable part of the power has to be converted into continuous current the rotary converter is the most efficient and reliable apparatus to use. Assuming a voltage of 300, a peripheral speed of commutator of 3,000 feet per min., width of segment ⅜ inch, and 10 volts per segment, we get 27 cycles as the upper limit of conservative converter design. Converters are in satisfactory operation at 60 or even 66 cycles, but only under favourable conditions as regards steadiness of power supply, low resistance of transmission line, careful attention to commutator, brushes, &c. The higher the frequency of a converter, the larger must be the number of poles. This requires that the armature reaction of the machine, considered as a continuous-current generator, must be high, to avoid cross-currents between the poles and unequal current distribution between the different sets of brushes of the same polarity, and consequent heating and sparking. With a machine of very low armature reaction, such as the 60-cycle converter (in which the space per pole on the armature is limited by the frequency), unequal current distribution may become serious. Also the high speed, and consequent high momentum, is apt to cause hunting. For these reasons it is very undesirable to adopt a higher frequency than 25 cycles for converter work, motor generators being preferable for conversion at higher frequencies. To suppress hunting the most efficient device is to use copper bridges between the field poles.

In the case of alternators running in parallel, experience has shown that a maximum difference in phase of 5 or 6 degrees is about the upper limit of good practice. This limitation is obviously much more difficult to secure with a large than with a small number of poles. It should preferably be secured by balancing the momentum of the reciprocating masses of the engine against the steam impulses, and not by very large flywheel capacity, since this tends to cause hunting. While the speed during each revolution should be as uniform as possible, it is preferable that the speed should drop several per cent. from no load to full load to insure good division of load between machines working in parallel.

A double current generator used as a converter is more liable to hunting, and a converter as double current generator to sparking and heating. The converter should have a high armature reaction to secure high output and stability, and a small conductor section to secure best commutation. Wherever the substations can be reached with 6,000 to 10,000 volts it is preferable to use alternators giving that pressure, these being just as reliable and efficient as low-voltage machines. In the generating station the main cables and feeders should be separated in a number of different conduits as far apart as possible. The operating switchboard should have no high-pressure conductors on it; instruments can be supplied from transformers, and switches can be operated by relays.

In the chain—generator, transmission line, transformer, converter—the transformer is the weakest link as regards overload capacity, and consequently it is best to allow a liberal margin in this apparatus. Air-blast is the best system of cooling, oil being too sluggish. It is desirable to give each converter unit a separate bank of transformers, in order to prevent pulsating cross-currents between converters, with consequent sparking and heating. Transformers and converter should be connected together permanently by conductors of the least possible length.

To regulate the bus-bar voltage of the substation, the alternating pressure on the converter has to be varied. This can be done by a switch controlling the number of working turns of the transformer primaries, or by inserting a special boosting transformer with primary in shunt and secondary in series with the circuit. The secondary coil is movable, and the variation of voltage is thus perfectly gradual. This regulator has the advantage of giving by its self-induction a flexible connection between converter and generator.

If a storage battery is used, it may be connected to the bus-bars through a series booster, which adds to the station voltage in charging and to the battery voltage in discharging, acting as generator in either case.

For series arc lighting, with a 60-cycle generating system, it is preferable to use alternating arcs. With a 25-cycle system there is a choice of methods: (1) Arc-lighting dynamos driven by synchronous or induction motors. (2) Constant current transformers and rectifiers. (3) Motor alternators or frequency converters, with constant current transformers. (4) A motor-driven constant current alternator feeding a number of arc circuits from series transformers. By this system circuits of different voltage and different current can be supplied from the same machine, and this generator may be of large capacity, instead of a number of small units as required with other systems. W. H. E.

269. *Switching Arrangements for Polyphase Circuits.* **H. Passavant.** (Elektrotechn. Zeitschr. 21. p. 767, Sept. 13, 1900.)—A short article giving the results of a discussion at the recent Kiel meeting of the Verband Deutscher Elektrotechniker as to the advisability of providing a break for each conductor of a polyphase system. The question was unanimously answered in the affirmative, a motor or other apparatus when switched off not being regarded as safe unless completely disconnected from all the supply conductors. A. H.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

270. *Barnsley Electricity Works.* (Elect. Engin. **26.** pp. 402–410, Sept. 21, 1900.)—The station is worked by the Corporation, and was opened in February, 1900. *System:* Continuous current, three-wire, at 230 volts per side, with batteries. The *boiler-house* contains three Lancashire boilers 28 ft. by 7 ft. 6 in. diameter, working at 160 lbs. The feed-water is heated by a Royles feed-water heater capable of raising the temperature of 2,000 gallons per hour from 55° F. to 200° F.; thence it passes through a Green's economiser of 192 tubes and a Kennedy water-meter. The coal is fed by an elevator into a conveyer running above the boilers, which supplies the hoppers of the Vicars' mechanical stokers. The *engine-room* contains three 75-kw. and one 150-kw. direct-driven sets, by Willans and Johnson & Phillips. The large engine indicates 250 h.p. at 380 r.p.m. with a pressure of 150 lbs. per square inch; the small ones are of 100 b.h.p. at 450 r.p.m. They are all non-condensing, with a specified consumption at full load of 26 lbs. of steam per b.h.p. hour. The dynamos are four-pole, giving respectively 155 kw. and 75 kw. at any e.m.f. between 460 and 520 volts. The combined efficiency of the sets (e.h.p.:i.h.p.) was specified to be not less than 81 per cent. The equipment also includes a balancing set capable of dealing with 75 amperes, and two boosters for charging the batteries, each capable of giving 130 amperes at 75 volts. The dynamos are designed with a view to working on a future traction load. The accumulators, supplied by Pritchetts and Gold, consist of 260 cells in glass boxes; their capacity is 500 ampere-hours at 100 amperes, or 300 ampere-hours at 300 amperes.

The *feeders,* of which there are three sets, are single cables by the British Insulated Wire Company, each set of 0·5, 0·2, and 0·5 square-inch sections; they are the paper-insulated, lead-covered type, laid in earthenware troughs and filled in solid with bitumen. The distributing cables, which supply about six miles of streets, have sections 0·25, 0·15, and 0·10 for the outer wires, with middle wires of about two-thirds of these sections. Lamps to the number of 8,340 8-c.p. or their equivalent were connected in July, 1900, with fifteen 10-ampere arc lamps, and thirty 16-c.p. incandescent lamps for the public lighting. G. H. B.

271. *Carlisle Electric Tramways.* (Tram. Rly. World, **9.** pp. 477–482, Oct., 1900.)—The system is overhead trolley, direct current at 500 volts with buffer batteries. Current is obtained from the City Supply Station at the following rates: For the first 50,000 units annually, 2d. per unit; for the next 100,000 units 1¾d.; and for further units 1½d. per unit. The length of track is 7¾ miles, consisting of 3¼ miles of single and 2¼ of double track. For the overhead line, side-pole construction is principally used, with a small amount of centre-pole work. The poles are of steel, drawn taper, 28 feet to 30 feet in length, with a diameter of 7 inches at the base. Cast-iron brackets support the trolley wire, which is run double throughout, and consists of No. 0 gauge with a breaking strain of 23 tons per square inch. The permanent way is laid with steel girder rails weighing 83 lbs. to the yard, at a gauge of 3 ft. 6 in. The rails are jointed by "Dicker" fishplates, and bonded by double Neptune bonds. The track foundation consists of 6 inches of cement and concrete, extending 2 feet outside the rails; the paving is of Whinstone setts. The feeders are Callender's vulcanised bitumen cables laid in Sykes' conduits; feeder pillars are arranged at half-mile intervals, each being in telephonic communication with the power station.

The rolling stock consists of 12 four-wheel motor cars, of which 9 are double-deck and 3 single-deck pattern; the bodies are built by the Electric Railway and Tramway Carriage Works, and are mounted on Brill 21-E trucks. The car length is 26 ft. 6 in., and the seating capacity of the double-deck cars is 43, and of the single-deck 22 passengers.

On the routes equipped there are no important gradients, the maximum being 1 in 14 for a distance of 60 yards; the curves are, however, sharp, the minimum radius being 40 feet. The erection of the whole plant has been carried out by Dick, Kerr & Co.

The plant erected at the Corporation Station is as follows: *Boiler-house:* Three Lancashire boilers 28 feet by 8 feet in diameter, by the Oldham Boiler Works Company, Limited. Each can evaporate 8,000 lbs. of water per hour at a pressure of 160 lbs. per square inch. They are fired by mechanical stokers by the Union Ironworks Company. The feed-water is heated by a Green's economiser of 384 tubes. *Engine-room:* Two 200-i.h.p. Willans-Siemens sets running at 350 r.p.m., and two of 100 i.h.p. at 460 r.p.m.; the latter are used as balancers. The larger engines gave the following tests: Pounds of water per i.h.p. at full load, 16·5; ¾ load, 17·2; ½ load, 18·0; ¼ load, 20·1; lbs. of water per e.h.p. at full load, 20·3; ¾ load, 22·3; ½ load, 25·2; ¼ load, 34·4. Each engine is fitted with a Ledward ejector condenser giving a vacuum of 26 inches of mercury.

There are now in course of erection two 400-i.h.p. Willans-Peebles sets running at 300 r.p.m.; they will be run compounded on the traction load and shunt on the lighting load. Also a booster by the Electric Construction Company, consisting of two 4·2-kw. generators mounted on either side of a motor. The voltage of all the generators can vary from 470 to 530 volts; their fields are separately excited at 230 volts. The secondary battery consists of 250 chloride cells in glass boxes. G. H. B.

272. *Glasgow Electricity Works.* (Electrician, 45. pp. 765–767, Sept. 14; 805–812, Sept. 21; and 849–852, Sept. 28, 1900.)—*System:* Continuous current, three-wire, at 250 + 250 volts, with batteries. In the Port Dundas station the *boiler-room* contains 10 Babcock and Wilcox boilers containing 4,020 square feet of heating surface and capable of evaporating 15,000 lbs. of water per hour at a pressure of 200 lbs. per square inch. They are fitted with Babcock and Wilcox superheaters. The steam main consists of a 15-inch mild-steel pipe. The feed-water is supplied by either a steam-driven or an electric motor-driven pump. Coal is stored in a 4,000-ton reserve bunker and in 60-ton steel tanks, one above the level of each boiler. It is fired by Babcock and Wilcox chain grates and mechanical stokers driven by electric motors. The clinker and ash is shot into an ash tunnel, from which it is removed by an electric tramway. The *engine-room* contains seven vertical sets. These are: (1) A 750-h.p. two-crank compound Ball & Wood engine with Corliss valves running at 150 r.p.m.; the cylinders are 20-inch and 44-inch by 24-inch stroke. (2) A 900-h.p. three-crank triple-expansion marine engine by Matthew Paul & Co., running at 120 r.p.m., with cylinders 17-inch, 25½-inch, and 38-inch by 30-inch stroke. (3) A 400-h.p. four-crank triple-expansion single-acting constant-thrust enclosed engine by the Mirrlees, Watson & Yaryan Company, running at 330 r.p.m. with cylinders 14-inch, 22-inch, and two of 24-inch by 24-inch stroke. (4) A 200-h.p. two-crank compound engine of similar type, running at 380 r.p.m., with cylinders 12-inch and 14-inch by 12-inch stroke. (5) and (6) Two 1,100-h.p. triple-expansion Belliss engines with one h.p., two i.p., and three l.p. cylinders on three cranks, and piston valves; speed 230 r.p.m. The engines are designed for an overload of 1,500 h.p. and have by-pass valves for this purpose. (7) One 1,100 Willans three-crank triple-expansion engine with similar provisions for overload as the Belliss engines. The condensing plant consists of five sets of independent surface condensers by Allen. Each has a cooling surface of 2,550 square feet. Engine No. 1 is directly coupled to two dynamos by the Walker Manufacturing Company. They are compound-wound eight-pole 250-volt machines and are used as balancers. Engine No. 2 drives directly a twelve-pole shunt-wound Schuckert dynamo. Engines 3 and 4 drive directly two shunt-wound two-pole Crompton dynamos, their outputs being respectively 125 kw. and 255 kw. at 500 to 600 volts. Engines 5 and 6 are direct-coupled to British Thomson-Houston compound-wound multipolar dynamos giving 500 to 600 volts. Engine 7 drives directly a Crompton twelve-pole compound-wound dynamo; the field magnets are of cast steel with laminated poles. The three last dynamos have throw-over switches enabling the series coils to be cut out. There are two motor balancers, namely, a four-pole 250 kw. Bruce-Peebles set and a two-pole 50-kw. Silvertown set; the latter is compound-wound and gives 150 amperes at 230 to 300 volts at a speed of 650 r.p.m. For charging the batteries there are two motor-driven boosters by Mavor and Coulson; the motors are shunt-wound and take current at 500 to 600 volts, and the boosters give 225 amperes at 20 to 160 volts, running at 850 r.p.m. They are separately excited at 350 volts. The *feeders* are triple concentric lead-covered cables, laid in iron, earthenware, or wood troughs filled in with insulating composition. All the feeders have conductors 1, 1 and 0·3 square-inch section, except four with sizes of 0·5, 0·5 and 0·25 square inch. They are tested to a pressure of 30,000 volts. Distributors of 0·25 square-inch section are laid in the main thoroughfares, and elsewhere are of 0·15 square-inch section. They are of the same type as the feeders. The contract for all the cables was equally divided between the British Insulated Wire Company and Callender's Construction Company. The station is equipped with 335 Tudor accumulators arranged in two batteries; with 25 pairs of regulating cells in each. The capacity is 1,100 ampere-hours at 150 amperes; the maximum discharge rate is 250 amperes. The cell boxes consist of sheet lead contained in a crate of cast lead; they are supported on steel girders covered with sheet lead, and are insulated by glass slabs standing on oil insulators. The regulating contacts are arranged along a girder fixed to the wall of the battery-room, contact being made by a trolley carriage running along the girder, and moved by a wire rope passing round drums which are geared to hand-wheels near the switchboard.

The switch gear is distributed on two sets of panels; the dynamo panels being on the engine-room floor and the feeder panels on a gallery above, the bus-bars running between the two. Each dynamo is provided with a separate positive and negative panel. The feeder panels are divided into sets supplying eight pairs of feeders and arranged in two rows one behind the other.

On the other side of the river, at a distance of nearly two miles, has been erected a second station, the Pollokshaws Road Works. Its equipment is very similar to that of the Port Dundas station, but as yet there are no accumulators; it is proposed, however, to remove two 200-volt Tudor batteries, now in sub-stations, and to erect them in the station, making them up to 250-volt batteries. The *boiler-room* contains four Babcock and Wilcox boilers of 1,100 h.p. each. The *engine-room* contains one 1,100-h.p. Willans-Crompton set, two 400-h.p. Belliss-Crompton sets, and two 200-h.p. Alley and McLellan-Mavor and Coulson sets.

The details of the supply during the year ending May 31, 1900, are as follows: Number of consumers, 2,852; number of public arc lamps, 265; maximum load, 4,258 kw.; units sold, 4,250,669; units generated, 5,226,818. The public arc lamps are connected in series of ten on the 500-volt outers.

The drawings in the article are: Map of feeders, views of engine-room, boiler-house and condensers, switchboards and battery-room; plans and elevation of both stations, the Belliss sets, the feeder panels, and street feeder and distributor boxes. G. H. B.

273. *Liverpool Power Stations.* (Electrician, 45. pp. 953–955, Oct. 19, 1900.)—Two new power stations have been erected by the Corporation at Pumpfields and Lister Drive for the purpose of supplying energy for lighting and tramways. The stations are about 2¼ miles apart, the line joining them passing through the middle of Liverpool. The arrangements at the two stations are practically similar. In each the plant is divided into four independent sections, consisting of seven boilers and economiser, and three steam dynamos and accessories. The *engine-rooms* are 247 feet long and 50 feet wide, with *boiler-houses* 53 feet wide on each side. The boilers are of the Lancashire type, 30 feet by 8 feet, with flues 3 ft. 2 in. diameter, five Galloway tubes being placed in the flues. They are fired by Vicars stokers. At Lister Drive the coal is delivered from the railway siding into a wrought-iron storage tank over the stokers; at Pumpfields it is delivered from the canal into a similar storage chamber by means of belt conveyers. The engines are by Willans, three-crank, and triple expansion, having a continuous output of 1,200 i.h.p. at 230 r.p.m. The cylinders are 15 inches, 20¼ inches, and 34⅝ inches in diameter, stroke 16⅞ inches; diameter of crank-shaft, 11 inches. The dynamos are by Siemens; they are multipolar and shunt-wound, with output of 1,420 amperes at 550 volts; the commutator consists of 560 sections, and is 57 inches in diameter. At Pumpfields, Körting ejector condensers are installed, there being one condenser for each engine, which requires 55,000 gallons of water per hour; the water is raised from the canal by centrifugal pumps to overhead tanks, each pump delivering 4,000 gallons per minute against a head of 50 feet. The pumps run at 365 revolutions, and have suction and discharge branches of 16 inches diameter, being steam driven. At Lister Drive there are Klein jet condensers, worked in connection with chimney coolers, the arrangements being described in some detail. It is impossible for any condensing water to enter the steam cylinders of the main engines, the exhaust steam main being carried to a height of 34 feet above the injection water-level, and arrangements are made for drawing off any water which may condense in this main below the barometric height. Each station has a battery-room with accommodation for 240 cells capable of giving an output of 200 amperes for one hour, or 80 amperes for four hours. There are also two switchboards, one for lighting and one for tramway purposes, separate dynamos being in general used for each. The coal elevators, ash elevators, mechanical stokers, and economiser scrapers are worked by motors varying from 2 h.p. to 12 h.p. These stations of course supplement those already existing, which had a capacity of about 10,000 h.p. A drawing is given showing the ground plan of the generating station at Lister Drive. W. H. S.

274. *Rochdale Electricity Works.* (Electrician, 45. pp. 955–957, Oct. 19, 1900.)—Current is supplied on the three-wire system at a pressure of 440 volts between the outers. The boilers are of the Lancashire type, 30 feet by 8 feet, working at a pressure of 150 lbs. The economiser contains 256 tubes; and the chimney is 150 feet high by 6 ft. 6 in. diameter. The feed pumps are of the three-throw type, geared to motors; each is capable of delivering 2,000 gallons per hour into the boilers. The motors are enclosed, each having two commutators for series-parallel running, and were constructed by Wilson Hartnell. There are two cast-iron storage tanks, one of 3,000 gallons capacity for cold water and the other of 2,500 gallons capacity for the hot well. The engine-room contains two Belliss engines, direct coupled to Siemens two-pole dynamos, having an output of 180 kw., as shunt machines; but a series coil has been provided so that the machines can also be used as compound-wound for tramway purposes. The steam is condensed in a surface condenser, capable of dealing with 12,000 lbs. of steam per hour. The engine-room has a 10-ton travelling crane with a span of 33 feet, and lift of 20 feet. The battery-room contains 252 cells, capable of giving a discharge of 60 amperes for ten hours, or 250 amperes for one hour. W. H. S.

275. *Bury St. Edmunds Electricity Works.* (Elect. Engin. 26. pp. 618–627, Nov. 2, 1900.)—A direct-current supply is given, the distribution being effected on the three-wire system. The *boiler-house* contains two Lancashire boilers, 28 feet by 7 feet, working at a pressure of 150 lbs. per square inch. There is an economiser of 96 tubes, and in addition a Chevalet heater-detartariser, used for the purpose of heating and softening the feed-water. This latter is capable of heating 540 gallons of water per hour to 212° F. There are two feed pumps, one electrically driven, capable of delivering 1,000 gallons per hour, and the other steam driven, capable of delivering 2,500 gallons per hour. The *engine-room* is 25 feet broad and 35 feet long. It contains two steam dynamos of 60 kw. capacity each, giving 130 amperes at 460 volts and 500 r.p.m. The battery-room is 32 feet long by 92 feet broad, and contains 252 cells, giving a discharge of 500 ampere-hours when discharged for ten hours. The mains are triple concentric, and armoured. Two feeders are laid, having a sectional area of 0·2 square inch in their outer conductors; and a third feeder has an area of 0·1 square inch. The distributors have a sectional area of 0·125 square inch. Several drawings are given, showing the design of the station and the switchboard connections. W. H. S.

276. *City and South London Electric Railway.* (Engineer, 90. pp. 346–349, Oct. 5, 1900.)—The extension of the City and South London Railway to Clapham Common and Moorgate Street, and the further and later extension to the "Angel" at Islington, necessitated so considerable an increase in the generating plant that it was decided to discard the old station and system of working and put down a new installation. The present article describes this new station erected at Stockwell on a site adjoining the original one.

The system adopted is the continuous-current three-wire system with balancers, at a pressure of 1,000 volts on the outers. The running rails form the middle wire, and in each tunnel the working conductor forms one outer. Each working conductor is fed at three points—Stockwell, Kennington, and London Bridge. The Kennington feeder is coupled through a booster to compensate for the drop in the feeder. At London Bridge is a battery substation, fed from the main board at Stockwell on the five-wire system, a motor generator maintaining a high tension feeder 500 volts above the bus-bars; the pressure is reduced to the normal at the substation. At Moorgate Street, the "Elephant and Castle," and Clapham Common, balancers are placed, each capable of dealing with a load of 160–200 amperes concentrated on one side of the system.

In the generating station the *boiler-house* contains nine Davey Paxman "Economic" boilers, 15 ft. 6 in. by 8 ft. 9 in. diameter, capable of evaporating 8,000 lbs. of water per hour each, at a pressure of 160 lbs per square inch. Over the boilers the coal is stored on a steel and concrete floor in wrought-iron bunkers of about 1,000 tons capacity. The coal is delivered to a hopper outside the boiler-house, and thence it is elevated and conveyed to the bunkers by an elevating and conveying plant erected by the New Conveyer Company of Birmingham. From the bunkers the coal is delivered by measuring shoots to the hoppers of the Vicars mechanical stokers with which the boilers are fitted. The main steam range is duplicated, and consists of lap-welded steel pipes with solid flanges, and is so arranged that no expansion joints are needed.

The *engine-room* contains two 800-kw. sets, two 300-kw. and two 125-kw., all direct-coupled. The engines of the 800-kw. sets are slow-speed Corliss compound engines by Cole, Marchent, and Morley; working at 150 lbs. per square inch pressure, they indicate 960 h.p. when running at 85 r.p.m. and condensing. The cylinders are 24-inch and 49-inch by 4-feet stroke; they are not steam-jacketed, nor is there any steam-jacketed intermediate receiver. The governor controls the expansion on both cylinders. The fly-wheel is 24 feet in diameter, and weighs 40 tons; it is constructed with solid steel plates on either side. The crank-shaft deflects about $\frac{1}{1000}$ inch in 2 feet, and to cover this the bearings are allowed to swivel a slight amount. Throwing on and off the full load of 800 kw. produces no appreciable variation in speed of the engine.

The guaranteed steam consumption is 16·3 lbs. per b.h.p. hour; from the makers' tests it came out just under 15 lbs. The 800-kw. generators coupled to these engines are by the Electric Construction Corporation. The field-magnet yoke, carrying fourteen steel poles, is divided on the vertical centre line, and provided with gear for separating the two halves. The armature spider is bolted directly to the flywheel centre, so as to preserve the shaft and keys from strains due to sudden fluctuations of load. The other generating sets are, with the exception of one 125-kw. Willans-Siemens set taken from the old station, also by the Electric Construction Corporation, but are coupled to high-speed Willans engines. The 300 and 125-kw. generators have respectively six and four poles, and commercial efficiencies of 93 per cent. and 92 per cent. The larger sets can run for four hours, giving 400 kw. without injury.

The condensing plant and cooling towers are arranged for a maximum of 52,000 lbs. of steam per hour. The condenser has a surface of 5,500 square feet, and is provided with two steam air-pumps. The water is cooled in three cooling towers by an induced draught; two towers were supplied by Klein & Co., and the third formed part of the old station. The water is circulated by a steam-driven and by a motor-driven pump.

At the London Bridge substation two reducing sets by the Electric Construction Corporation take current from the feeders at an extreme pressure of 2,000 volts, and deliver at 500 volts on each side of the three-wire system, automatically compensating for the pressure drop in the feeders. Their rated capacity is 300 kw. continuously, or 400 kw. for two hours. At full, half, and quarter loads the efficiencies of the reducers are respectively 95½ per cent., 92½ per cent., and 89 per cent., while including the feeder loss they are 88 per cent., 89 per cents., and 87 per cent. There is also a battery of 556 No. 49 H.B. 11 type Tudor accumulators of 450 ampere-hours' capacity, discharging at 150 amperes, or 350 ampere-hours at 350 amperes; boosters are provided for charging.

The contract for the complete electrical equipment was let to the Electric Construction Corporation, with, as sub-contractors, Willans and Robinson, Cole, Marchent, and Morley, the Tudor Accumulator Company, and Callender's Cable Company. The condensing plant was erected by Cole, Marchent, and Morley, the boilers by Davey, Paxman & Co., and the coal-handling plant by the New Conveyer Company.

The drawings include plan and section of the station, plan and elevation of the Corliss engine, and side and end views of the 800-kw. generator, with two photographic views of the large generating set. G. H. B.

277. *Blackpool and Fleetwood Tramway.* **T. G. Lumb.** (Elect. Engin. **26.** pp. 199–201, Aug. 10, 1900. From the Transactions of the Royal Institution of Public Health.)—This line, 8½ miles long, is one of the best-paying lines in the world. In its first twelve weeks it carried 550,000 passengers with only ten open cars. In Blackpool and Fleetwood the lines are laid as a tramway paved with granite setts. Between the two towns light railway construction is used, and the line is fenced in and passes through several cuttings. There are ten level crossings, all provided with cattle guards. On the tramway section ordinary girder rails are used, weighing 83–98 lbs. per yard, and bonded with two Daniel bonds. On the light-railway section 56-lb. Vignoles rails are spiked to creosoted redwood sleepers embedded in 12 inches of ballast. Round curves, fangbolts and clips fix the rails. Plastic rail bonds are used consisting of plastic metal in a cork case, which is clamped up between rail and fish-plate.

The generating station is 2 miles from Blackpool and ¼ mile from the line. Alongside is a car-shed 170 feet by 67 feet, holding twenty-four cars. The plant comprises four Galloway Lancashire boilers, 30 feet by 8 feet diameter, built for 120 lbs. per square inch. Water is drawn from a reservoir, close to engine-room, fed by surface springs, or alternatively from the public supply through a storage tank. A Klein cooling tower is used. The feed-water is heated by a Green's economiser with 288 tubes. The steam main is a ring, and both it and the branches to each engine are provided with steam separators. The steam and exhaust-pipes are in a basement under the engine-room. The engine-room contains five Mather and Platt open marine-type vertical compound engines with cylinders 12 inches and 24 inches by 16 inches stroke, each giving 200 h.p. at 175 r.p.m.; these are direct-coupled to six-pole dynamos, giving 120 kw. at 505 volts. Ledward ejector condensers are used, and take their water from the storage tank. After leaving the condensers the water is cooled by passing down a wooden trough and some distance round the reservoir before entering it. Steam-driven centrifugal pumps circulate the water. The dynamos are shunt-wound, and are peculiar in having a collar connecting the field coils and encircling the armature; this arrangement effectually prevents all sparking. The efficiency of the machines is 93 per cent. Three 26-kw. boosters are provided, each consisting of a motor connected to the bus-bars, direct-coupled to a generator giving 130 amperes at 200 volts. By means of suitable switches any feeder may be connected to a booster, and thereby the pressure at its feeding-point kept constant. This allows all the dynamos to be run in parallel at the same voltage, and all the feeders to be of the same size. The boosters are also used in charging the accumulators independently of the line. The feeders are $^{37}/_{14}$ lead-covered and armoured cables laid in trenches alongside the track. One feeder runs direct to an accumulator station near the Fleetwood terminus, where there are 250 300-ampere-hour chloride cells. The principal function of the battery is as a regulator, but it is also used to operate the cars early and late. Double trolley wire, 0·348 inch diameter, is used throughout, fixed to brass ears insulated from the pole arms with Etna insulators. In Blackpool the suspension is by bracket side-arms, except where the width of the road necessitates span wires; elsewhere centre poles with double bracket-arms are employed. The Company now has twelve open and twelve closed cars, and three trailers, with twelve more on order. Each motor-car is 34 ft. 5 in. long, is mounted on two bogie trucks with 28-inch wheels, seats 48 passengers, and weighs 12 tons loaded. Each bogie carries a G. E.-1,000 motor, rated at 35 h.p., and driving through 4 : 1 single-reduction gear. There are no outside seats. E. H. C.-H.

278. *Perugia Electric Light and Traction System.* (Elettricità, Milan, 19. pp. 561–566, Sept. 8, 1900.)—*System:* Continuous current, three-wire, at 220 + 220 volts, with batteries. The *boiler-room* contains three water-tube boilers by Tosi, working at a pressure of 10 atmospheres; their dimensions are: Heating surface, 167 sq. m.; number of tubes, 81; size of tubes, 102 × 5,500 mm.; size of boiler, 7,430 × 1,400 mm. diameter. The feed-water is treated with sodium carbonate in a purifier. The boilers are fired by hand. The *engine-room* contains three vertical compound tandem engines by Tosi; two are for lighting, and give 170 b.h.p. at 9 atmospheres pressure and 200 r.p.m. The cylinder diameters are 375 and 600 mm., with a stroke of 425 mm. The third is for traction, and is of the same type, with cylinders 300 and 475 mm. and a stroke of 350 mm.; it gives 120 b.h.p. at 250 r.p.m. The condensers are sufficient for 6,000 kg. of steam per hour, and have a cooling tower by Balke & Co.

The two lighting engines drive directly two Siemens and Halske dynamos, type T. $\frac{76}{31}$, giving 135 to 110 kw. at 500 to 440 volts. The engine for traction drives a similar dynamo, giving 100 kw. at 500 to 550 volts. Two Siemens and Halske motors, type U.A. $\frac{18}{28}$, of 38 h.p., each running at 650 to 720 r.p.m. at 220 to 245 volts, drive two dynamos serving as boosters and balancers; the latter give together 50 kw. at a pressure of from 40 to 200 volts. The station is equipped with a battery of 264 Tudor elements of a capacity of 756 ampere-hours for three hours, or 1,015 ampere-hours for ten hours; this battery is for lighting. Another battery for traction has 256 Tudor cells with a capacity of 165 ampere-hours for one hour.

All the feeders and distributors are overhead bare copper wires supported on poles or brackets. There are seven feeders, one of 120 sq. mm. section, three of 70, and three of 50. For public lighting there are forty-four 8-ampere arc lamps run nine in series on 440 volts or four on 220 volts, and about 100 incandescent lamps of 16 and 32 c.p.

The tramway track, 5,100 m. in length, is equipped on the trolley system, with two Siemens collectors on each car. The trolley wire, 8 mm. in diameter, is carried on span wires between the houses. The rails are of Phœnix type, weighing 42·8 kg. per metre, and 150 mm. high. They are tied together at a gauge of 1 m. by flat iron ties 1·8 m. apart. The joints are bonded by bonds 8 mm. in diameter of the Chicago type. There are three motor-cars, two passenger trailers, and two goods trailers. The motor-cars are equipped with two Siemens motors of 25 to 30 h.p. each, and have a capacity of twenty-four passengers, while the trailers can take thirty. The maximum speed is 25 km. per hour. No drawings accompany the article. G. H. B.

279. *Electric Traction in Kansas City.* (Street Rly. Journ. 16. pp. 741–760, Oct., 1900.)—On account of very heavy grades there were 63 miles of track in Kansas City operated by cable; all these lines have been converted to electric traction except those in two streets, where the grades reach 18·5 per cent. The total length of track of the chief company is 160 miles. All track is laid with centre-bearing rails with the ball of the rail above the street level, in order to comply with City Ordinances. All recent rails are 108-lb. centre-bearing girder rails in 60-feet lengths. No ties are used in streets which are asphalted from kerb to kerb, reliance being placed on the non-movable character of this paving. Falk cast-welded joints have been found very satisfactory on 6-inch and 9-inch rails, but on 4½-inch rails there have been many breakages at welded joints.

The cars have gates, and no one can enter or leave without the motor-man opening them. On a suburban line an electric locomotive is used for coal haulage and construction work. Its controllers are said to be the only ones which will successfully operate four motors in series, series-parallel, or all in parallel without the use of any auxiliary commutating switch, and with one revolution of the handle. Power for almost all the lines is supplied from a station on the Kaw River containing 7,000 h.p. in engine capacity. A new large unit consists of a 2,500-h.p. Allis-Corliss engine direct-coupled to a 1,600-kw. G.E. generator with a 40 per cent. overload capacity for three hours. The engine exhausts into an independent Wheeler condenser having 5,000 square feet of cooling surface; its shaft is of hollow-forged, fluid-compressed steel; its flywheel is 24 feet in diameter and weighs 160,000 lbs.

The cable cars are driven from a station where a 300-kw. compound-wound motor operates 24,000 feet of cable carrying sixteen trains on a line having one 10 per cent. grade. The ordinary motor input is 200–600 amperes, running up to 800 amperes on heavy days. The cable on the steepest route has to be renewed every forty days, and is then transferred to lighter routes, where it lasts about six or nine months. The cables run at 12 miles per hour.

The Kaw River station is amongst the most economical in the world. For the first seven months of 1900 the average total cost of power, exclusive of interest, taxes, and insurance, was $·0041 per kw. hour, the cost of coal being about $1·20 per ton. The load was usually taken by two 1,200-kw. units, with a 550-kw. set to take the "owl-car" load. Eleven men are required to run the plant during the twenty-four hours. For another station on the Blue River the corresponding figure for the same period was $·0079, or nearly double the Kaw River figure. The difference in fuel consumption per kw.-hour is almost as great. Both stations are well equipped and modern, are owned by the same company, and operated in the same manner. The differences in equipment are: Large as against small direct-connected units, compound-condensing as against simple-condensing engines, water-tube as against tubular horizontal boilers, and mechanical as against manual stoking. The comparison is a strong argument in favour of replacing small stations by one large station with large units.

An interurban line runs out 26 miles from Kansas City to Leavenworth almost entirely on its own right-of-way. The track and wheels are of standard steam railway form, permitting very high speeds. Spring switches are used at turnouts in order to enable cars to run through them at high speed. The trolley wire is 8-shaped. The feeders are of bare aluminium of 362,000 circ. mils. section. There are four competing steam railroads. There are ten electric cars, 41 feet long by 9 feet wide overall, weighing 22 tons each. They carry four steel 50-h.p. motors each, geared to give 45 miles per hour, and one controller. The Magann storage air-brake system is used with success in spite of the length of run between charges, which are only taken at the power station midway, where an Ingersoll-Sergeant compressor gives 300 lbs. per square inch. The storage tanks hold enough charge for 100 miles' run. The pressure is brought down between the tank and the brake cylinder to 45 lbs. per square inch by a reducing valve. E. H. C.-H.

280. *Rotary-Transformer Stations at Buffalo.* **R. E. Danforth.** (Street Rly. Journ. 16. pp. 893–895, Oct., 1900. Paper read before New York State Street Railway Association, Sept., 1900.)—An account is given of the scheme referred to in Abstract No. 389 (1900.) The rotary converters are six-pole machines and run at 500 r.p.m. They are fitted with magnetic oscillators which give the shaft an endwise pull at regular intervals of a few seconds, thus preventing the brushes from wearing tracks. The windings of converters above 500 kw. are connected to the step-down transformers as six-phase instead of three-phase in order to increase the efficiency by reducing the losses in the armature winding. The connection of the armature winding to the collector-rings serves incidentally the same purpose as the equaliser-rings used on parallel-wound generators, equalising the field strength under all poles and improving commutation. A description of the switch gear and of the methods of starting up the converters is given. Each of the four substations has one attendant. E. K. S.

281. *The Engins Electric Power Station.* **J. L. Routin.** (Ecl. Électr. 25. pp. 24–45, Oct. 6, 1900.)—A full description of the power plant for a large electric transmission near Grenoble, with 15,000 volts on the line. The power station is on the Furon, which feeds the Isere River, the height of the fall utilised being 282 m. The three-phase alternators are of the Labour type, and give 350 kw. at 125 volts, which is raised by three-limb step-up transformers to 15,000 volts. The electrical plant has been mostly supplied by the Société l'Eclairage Electrique of Paris and G. Grammont of Pont-de-Chérui. Illustrations show the high-tension line where it crosses the Isere in a very long span ; also the railway line where a special steel bridge has been provided. Very complete particulars of tests for efficiency, &c., are given at the end of the article. E. K. S.

282. *Buenos Ayres Lighting and Tramway Station.* (Elect. Rev. 47. pp. 61–65, July 13 ; 95–96, July 20 ; 239–240, Aug. 10 ; and 265–266, Aug. 17, 1900.) —*System:* Single-phase alternating-current at 3,400 volts with transformer substations supplying a three-wire network with 230 volts on the outers for lighting, three-phase current for power, and continuous current for traction. The *boiler-room* contains eight Belleville water-tube boilers, each with 10 sets of 12 tubes, inclined at an angle of 2½°. The heating surface of each boiler is 106 sq. m., and the output 3,750 kg. of steam per hour. Steam is discharged downwards from nozzles in a pipe fixed 12 inches above the fire-bars, with a view to mixing the furnace gases. The feed-water is heated by an economiser placed above each boiler. The boiler working pressure is 225 lbs. per square inch. The steam is taken by a ring main to a group of reducing valves, one for each engine, and the pressure can by these be regulated by hand within a range of 40 to 130 lbs. per square inch. The *engine-room* contains four 500-kw. Allis-Corliss horizontal compound engines, and two Gritzner vertical engines, with piston valves, driving exciters. The main engines have cylinders 20-inch. and 40-inch. with 36-inch. stroke, and run at 125 r.p.m. They have a flywheel 12 feet in diameter weighing 17½ tons. The cut-off is regulated by a Reynolds governor. The exciter engines have cylinders 225 and 340 mm. with stroke

of 240 mm. and run at 325 r.p.m. In an adjoining temporary engine-room for traction generators are one McIntosh and Seymour 500-kw. vertical triple-expansion three-crank engine with gridiron valves controlled by a flywheel governor, and two of the same makers' compound tandem engines with piston valves. The cylinders of the former engine are 14, 23, and 40-inch, with 36-inch stroke ; the speed is 125 r.p.m. Those of the latter engines are 11 and 19-inch, with 23-inch stroke ; the speed is 230 r.p.m. Each engine is connected to an independent Wheeler surface condenser of 1,000-h.p. capacity. Each of the Allis-Corliss engines drives between its cranks a 500-kw. 3,400-volt monocyclic alternator of the revolving field type. The alternator has a principal single-phase winding with a supplementary power winding of about one-quarter the capacity connected with the principal winding at its central point and giving three-phase current. The field-coils are 48 in number. The Gritzner engines drive directly two multipolar compound-wound exciters, giving 30 kw. at 130 volts. Another similar exciter is driven by a 50-h.p. 8-pole three-phase motor through a flexible coupling at a speed of 750 r.p.m., the motor taking current from transformers at 230 volts. In the temporary station the tramway generators are—one multipolar direct-driven 500 kw. 500-volt dynamo and two similar ones of 225 and 100 kw. To the last can be belted a 100-kw. monocyclic alternator of the revolving armature type, arranged to run as a motor or as a generator. A storage battery is to be installed as a reserve for excitation. The primary and secondary *feeders* are triple-cored, lead-sheathed and armoured cables, laid in trenches under the pavement, on a layer of sand ; they are covered by a second layer of sand and bricks ; at street-crossings they are laid in iron pipes. Seven inter-connected feeders go to the principal substations, and from these primary cables distribute to other substations. The heaviest feeder has two cores of 170 sq. mm. and one of 60 sq. mm. ; the heaviest primary cable has two cores of 50 sq. mm. and one of 16 sq. mm. ; the heaviest secondary cable has three cores of 95 sq. mm. There are 50 transformer substations, each for four 30-kw transformers. Boosting transformers enable the pressure at each feeding-point to be regulated. The cables are by Felten and Guilleaume. For supplying polyphase motors additional cables are run from the nearest substation. Fifteen-ampere street arc lamps, to the number of 350, are run off small transformers with ratio 230/33. There are at present installed 50,000 16-c.p. lamps and 300 h.p. in induction motors. The price charged for lighting is 25 cents per unit with discounts on a sliding scale from 5 per cent. for a monthly consumption of over 25 units to 20 per cent. for 200 units, and an additional discount depending on the average annual time of burning per lamp, varying from 5 per cent. for 500 hours to 20 per cent. for 2,000 hours. The price for power is 12½ cents per unit. The tramway lines operated electrically include 13 miles of double track and 5 miles still under construction. The system is overhead trolley. The rails are 6⅝ inches high, and weigh 86 lbs. per yard. For a certain length their joints are cast-welded on the Falk system, with Chicago bonds round the welds ; the rest of the track is bonded with Edison-Brown plastic bonds and one Chicago bond. The track is laid on three systems : in the streets, with wood pavement, it is laid on a concrete base the width of the track ; towards the outskirts, where the paving is composed of granite setts, on longitudinal concrete sleepers ; and in the suburbs, where there are macadamised roads, on native hard-wood sleepers on a foundation of broken stone. Feeders and distributors are laid underground, and are paper-insulated lead-sheathed cables by the British Insulated Wire Company, drawn into Doulton stoneware conduits. At feeding-points are placed pillars containing switch, fuse, lightning arrester and telephone to station. The drop of voltage is kept within Board of Trade limits by two negative boosters driven by shunt-wound motors. The overhead line is carried, according to circumstances, on span-wires between houses or between poles, on centre poles with double arms, or on side poles with single arms. The trolley wire is No. 00. The cars, ninety-six in number, are of various types, double-truck double-deckers with top roof, combination open and closed cars, and open cars with reversible transverse seats. The trucks are of the Peckham extension pattern. Each car has two G.E.-1,000 motors, and is fitted with series-parallel controllers and electric brakes. G. H. B.

283. *Indiana Electric Tramways.* (Street Rly. Rev. 10. pp. 424–432, Aug., 1900.)—The tramway system of the Indiana Railways Company consists of 42 miles of track, almost the whole of which is single, and serves a population of about 70,000. The track is laid with T-rails weighing 70 lbs. per yard, 4⅝ inches high in the country, 7 inches high in paved streets, and either 30 feet or 60 feet in length. The rails are laid on oak ties, and are bonded with No. 0000 Washburn and Moen bonds, single bonds being used with low rails and double with 7-inch rails. In paved streets the foundation consists of gravel 6 inches deep, on which the ties are laid at intervals of 2 feet, the spaces being filled with concrete. Wooden poles are used except in main streets, with span wires almost throughout. It is intended eventually to utilise water-power, but at present there are three steam-power stations. The South Bend station contains five tubular boilers, one feed-water heater, two Buckeye simple non-condensing engines with cylinders 26½ inches diameter and 36-inch stroke, running at 125 r.p.m., and two 250-kw. Westinghouse generators driven by belt. The steam pressure is 100 lbs. per square inch; the feed-water contains lime and magnesia, and sodium triphosphate is used to soften it. There is also a 3,000-light Westinghouse steam-alternator for lighting service. At Osceola there are three tubular boilers working at 100 lbs., one feed-water heater, two 22-inch × 33-inch simple non-condensing Buckeye engines belted to a 200-kw. General Electric and a 250-kw. Westinghouse generator. Wurts tank lightning arresters are used. At Dunlap there are three tubular boilers, and one simple Allis engine driving three generators at 900 r.p.m. by belt. The total daily consumption of fuel averages about 17 tons of coal, costing 11s. per ton. There are several overhead feeders, tapped into the trolley line at intervals of 1,000–1,500 feet. The cars number 31 open and 21 closed on single trucks, 10 interurban double-truck cars, and 8 open trailers. The interurban cars measure 42 feet overall, and are equipped with four 49A Westinghouse motors and McGuire trucks; they carry 44 passengers each. The smaller motor-cars are of similar type, with two motors each. Full details of the system of accounts and report forms used by the company are given in the article. A. H. A.

284. *Street Railways in Portland, Me.* **C. B. Fairchild.** (Street Rly. Rev. 10. pp. 485–494, Sept., 1900.)—The city of Portland has 46 miles of track owned by the Portland Railroad Company, as well as an interurban line running 14 miles out to Yarmouth. A new power house to operate all the city lines is situated on tide water, and contains a 1,500-h.p. vertical-compound engine coupled direct to a 1,050-kw. G.E. generator. The engine has cylinders 26 and 50 × 42 inches, and runs at 100 r.p.m. with 120 lbs. steam pressure. The throttle is controlled from three positions by means of hand-wheels—one on the floor and one on each platform. The valve gear is of the Rice and Sargent type, and has silent vacuum dash-pots. The flywheel weighs about 85,000 lbs., and the diameter of the main shaft at the armature is 22 inches. All the valves have double ports, and the exhaust valves are set nearer to the piston than the steam valves, so that the clearance is largely reduced. The valves are operated by direct motion from the eccentrics without the medium of wrist plates. There are two eccentrics, one for the inlet valves and one for the exhaust, on each cylinder. The range of cut-off is from zero to ¾-stroke, which gives the engine great capacity for overloads and ensures perfect regulation under any condition of load. The cut-off latches operate without springs, dropping by their own weight, and are so constructed that the pressure from the eccentrics is on a line below the pivotal point, so that the latch cannot jump up. The wearing-contact plates on the latches are square, and are made of hardened steel, so that by shifting a plate and turning it over there are eight corners for wear. The point of cut-off is determined by a rod from the governor which actuates a yoke behind the latch, operating by means of rollers on a curved lever also attached to the cut-off. In connection with the governor is a safety device, designed to cut off the steam in case the governor belt should break or fail to work properly. The connecting rod is so designed that by removing one bolt it can be detached from the crank-pin, and being swung to one side the engine can be run by one cylinder if required. When it is found necessary to remove the connecting rod it can be swung out sideways through an opening in the frame. The flywheel is built in eight sections, each section consisting of a piece of the rim and an arm. E. H. C.-H.

285. *Quebec Tramways.* **D. E. Blair.** (Canad. Elect. News, 10. pp. 179–182, Sept., 1900. Paper read before the Canadian Electrical Association at Kingston, Ont., Aug., 1900.)—The gradients and curves on the City of Quebec tramway lines are exceptionally severe ; the gradients reach 15 per cent. in places, and numerous curves have radii as low as 35 to 40 feet. The speed on down-grades is limited to 4 miles per hour—a precaution which has resulted in an almost complete immunity from accidents. The average speed is 8 miles per hour. Hand-brakes with 100 : 1 leverage are exclusively used ; the brake shoes, weighing 19½ lbs., last 6,150 miles. The car wheels are of chilled cast iron ; of those removed during the first three years' working, 75 per cent. were worn out, 18½ per cent. had flats, and 6½ per cent. had flanges broken. The expenses incurred in clearing away snow are very heavy, amounting to $1·54 per car-day on an average throughout the year.

During the four winter months it requires 5·1 kw. to heat each car, and during November and April half that amount.

This electric railway, as well as all the lights and motors in Quebec, is operated through a substation within the city, the power being derived from the Falls of Montmorency. The power house contains three 600-kw. and one 750-kw. two-phase, 66 cycle 5,500-volt alternators ; one 600-kw. double-current 273–500-volt Westinghouse generator, besides exciters, &c. The power is transmitted to the city over 16 wires, carried on two separate pole lines. The substation contains two 600-kw. two-phase synchronous 5,000-volt motors, direct-coupled to two 500-kw. 550-volt G.E. railway generators. There are also two 200-kw. synchronous motors for driving four Brush arc lighters.

The paper concludes with particulars of an electric railway, 21 miles long, between Quebec and the Shrine of St. Anne de Beaupré. E. K. S.

286. *Electric Transmission Plants at Moodie's, De Kaap Goldfields, Transvaal.* **H. J. S. Heather.** (Inst. Civ. Engin., Proc. 141. pp. 269–306, Aug., 1900.)—The author describes his four years' experience in the management of a power transmission plant in the mountainous district of Lydenburg, South Africa. The motive power was water, and all the turbines, regulating gear, pipes, &c., were supplied by the Pelton Water-Wheel Company of New York. The first electric plant was put down in 1894 by Messrs. Goolden & Co. Two separately excited continuous-current generators were supplied, which gave 1,500 volts at 500 r.p.m. They were connected in series, so that the pressure at the generating end of the line was 3,000 volts. The current was conveyed a distance of 23,700 feet by means of overhead wires to a substation, where it actuated two motor generators, the motor armatures of which were in series and the generator armatures in parallel at a pressure of 625 volts. At the low-pressure switchboard it was divided into five separate circuits and distributed to the various mines. It was found that two 11-h.p. motors were barely sufficient to work a ten-stamp mill, each stamp weighing 950 lbs. with an 8-inch drop and making 92 blows per minute, together with four Scoular concentrating tables and a 15-inch Blake-Marsden stone-breaker. In order to avoid overloading, it was necessary to hang up one of the stamps. The weak points of this 3,000-volt direct-current system were: (1) Its low efficiency (only 51·5 per cent. reckoning from the generator terminals, (2) the cost of the upkeep of the substation, (3) the impossibility of running the plant during the frequent tropical thunderstorms, and (4) the uncertainty of the telephone service, which was a necessary adjunct.

In 1895 Rennert and Lenz, of Johannesburg, replaced the direct current by a three-phase alternating plant. Four three-phase generators were provided, each capable of giving 100 kw. at 200 volts at a speed of 430 r.p.m. By means of transformers the pressure was raised to 10,000 volts, which was the pressure adopted for transmission. The transformers at each end were star wound, the neutral points being insulated from both frames and earth. Three 50- and two 30-h.p. motors were supplied at first, but, as they had short-circuited rotors, their operation at starting was unsatisfactory. In the latter type of motor, supplied by the Allgemeine Elektricitäts Gesellschaft of Berlin, a variable resistance was inserted in the rotor circuit at the start, and the motors worked satisfactorily. The regulation of the Pelton wheels was effected automatically by deflecting the nozzles, but after a time the sand and mud made the flexible joint so stiff that the regulating gear failed to act. In order to prevent the water-wheels racing an ingenious arrangement was devised to keep the load constant; when the load was taken off and the water-wheel consequently quickened, an artificial load was automatically introduced into the circuit. The first forms of lightning arresters used proved inefficient to protect the lines during the tropical thunderstorms. A form supplied by Siemens and Halske in 1897 proved effectual. It was very similar to the Thomson-Houston arrester, and, although simpler, worked on the same principle. In experimenting on these arresters by starting artificial arcs the author found that when one arced to earth it invariably caused the 10,000 volts to arc across the three-eighths inch air-space of a neighbouring arrester; the author can give no explanation of this. While putting up the lines workmen often got severe shocks four or five hours before thunder became audible. It was found that certain parts of the line were liable to electric discharges, and so arresters were fitted at these points. These parts of the line were not necessarily the highest, and there was no apparent cause for their liability. The telephone arresters were of the Post

Office pattern and worked satisfactorily, although on several occasions the violent discharges caused drops of molten metal to earth one or both wires. The author suggests the use of carbon instead of metal for lightning arresters. Comparing the new three-phase with the old direct-current system, the author sums up as follows: (1) The saleable output for a given quantity of water was increased 50 per cent. (2) The staff and other expenses were reduced 50 per cent. (3) It was possible to work during thunderstorms. (4) There was no need for a telephone service. (5) Three-phase generators and motors are less liable to breakdown. (6) The motor speeds remained constant.

A. R.

287. *Graz Electric Tramways.* **P. Poschenrieder.** (Zeitschr. Elektrotechn., Wien, 18. pp. 417–422, Aug. 26, and 429–435, Sept. 2, 1900.)—A detailed description is given of a tramway installation carried out by Siemens and Halske. Particulars of a fuel and steam-consumption test are given, and also a full list of the tramway staff and the duties of each member. The generating plant consists of three single-crank Corliss tandem-compound horizontal engines driving eight-pole dynamos. There is also a Laval steam turbine.

E. K. S.

288. *Lachine Rapids Power Station.* **C. T. Child.** (Elect. Rev. N.Y., 37. pp. 244–250, Sept. 12, 1900.)—The station has been erected to utilise the water-power of the Lachine Rapids in Montreal for lighting and power purposes.

A forebay 1,000 feet wide has been formed in the Rapids by the construction of a dam 4,000 feet long, consisting of crib-work ballasted with broken rock, filled with small material and covered with stone. The depth in the forebay is 18 feet. The fall in the Rapids of 20 to 25 feet per mile gives an available fall at the turbines of 16 feet. At the lower end of the forebay is built a solid masonry dam, on which the power house is situated. Here are erected 72 turbines of 300 h.p. each; they have vertical shafts and cylinder-gate wheels 54 inches in diameter. The wheels are set in flumes, the shafts ascending through the flumes, every six gearing into a common shaft actuating one dynamo. Two types of governors are used—the Giessler electro-mechanical governor and the Lombard governor; each controls the gates of a set of six turbines.

The generators are General Electric three-phase machines with revolving fields of 40 poles; each develops 750 kw. at 175 r.p.m.; their voltage is 4,400 on each phase. The exciters, also by the General Electric Company, are driven in pairs by an independently governed water-wheel; they give 75 kw. at 150 volts running at 660 r.p.m.; they are four-pole and compound-wound.

From a tower at one end of the power house a transmission line 32,000 feet long runs to the McCord substation, where two synchronous motors are installed, each driving two 125-light direct-current arc machines. The transmission line consists of twelve three-phase lines (36 wires in all), consisting of No. 0 copper wire mounted on triple-petticoat porcelain insulators carried by wooden cross-arms on steel poles. These poles are built up of four steel angle-irons riveted together with latticed strips between; they are 29 feet in height. The line crosses the Lachine canal in cables run in a conduit 33 feet below the water-level. The twelve lines are normally run in parallel; they supply the synchronous motors through three 150-kw. oil transformers of ratio 4,000 : 2,000, with water-cooling pipes in the oil. There are also four 250-kw. transformers transforming to 2,300 volts, and three of 30 kw. each to 225 volts, the latter being used as boosters to the 150-kw. transformers. All the transformers are by the Wagner Electric Manufacturing Co. This substation supplies twenty 2,400-volt distributing circuits, one 4,000-volt circuit to the Imperial Electric Light and Power Station, and two to the plant of the Standard Electric Light and Power Company. The high-tension distributing system is laid underground and feeds the 110-volt overhead network through transformers carried on poles.

The present load is about 75,000 lamps and from 2,500 to 3,000 h.p. in motors. G. H. B.

289. *Alternate-Current Motors in a Textile Mill.* **A. F. M'Kissick.** (Amer. Electn. 12. pp. 513–515, Nov., 1900.)—In 1894 the Columbia Mills at Columbia, S.C., put down a water-power electric plant to drive a new mill of 68,000 spindles. The power house, 2½ miles from the mills, has wheel-pits and feeders for five pairs of horizontal wheels, each pair capable of giving 1,200 h.p. Three G.E. three-phase generators have been installed of the revolving armature type, giving 750 kw. at 3,600 volts and 60 cycles per second. The turbines are "Victors," with Giesler electro-mechanical governors. The generators, which feed the lines direct without transformers, are worked in parallel, all three machines being connected together before starting up, and the excitation raised as the speed rises; this method of paralleling is found easy and satisfactory. An old mill, formerly driven by a 450-h.p. engine, is now operated by ropes from a self-starting synchronous motor at 3,000 volts. The new mill contains 28 motors, also three 275-kw. and six 165-k.w. transformers, cooled by two 10-h.p. air-blast fans as well as a suction fan. The powers provided for the various operations are: One 50-h.p. motor for the cloth-room machinery and elevators; one ditto for aerophor pumps and heating apparatus; four 75-h.p. motors for picker-room machinery; four 130-h.p. motors for operating 1,580 looms; one 130-h.p. motor for operating 28 spinning-frames; three 130-h.p. motors and two 30-h.p. motors for operating carding-room machinery; nine 130-h.p. motors and four 50-h.p. motors for operating spinning-frames. The motors are attached to the ceilings. Owing to the amount of "lint" and "flyings" in the spinning and carding-rooms, it has been found necessary to use the squirrel-cage type of motor, which takes a very heavy starting current, but when once started runs satisfactorily. All the other motors are of the clutch type, with variable resistance in the rotor. In order to increase the power factor of the plant an over-excited synchronous 400-kw. motor has been installed, to run light and act as a rotary condenser. It is connected in parallel with the secondary 220-volt mains, and reduces the wattless currents, and therefore the temperatures, in the transformer-lines and the generators as well as the inductive drop. Without the condenser-motor the generator e.m.f. was 3,780 volts, the current output 435 amperes, and the power factor of the plant 0·86. With it, these figures respectively became 3,690, 402, and 0·94. It was found that more power was required in winter than in summer and in the early morning than at midday; consequently it is economical to keep the mills always well heated and dry. E. H. C.-H.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

290. *Guard Wires and Overhead Construction.* **S. Woodfield.** (Elect. Rev. 47. pp. 448–449, Sept. 21, 1900.)—On modern trolley standards a stop prevents the pole rising sufficiently to foul the overhead wires, but there is nothing to prevent its swinging round and fouling a suspension pole. The author suggests doubling the distance of guard wires above the trolley wire, in order to minimise the chances of the trolley pole fouling it, or of broken telephone wires coming into contact with the trolley wire. Shallow grooved ears with lugs at the ends are being gradually replaced by deep grooved ones without lugs; ears are now being made up to 42 inches for curves. "Pull-off" wires are being superseded by placing more poles round curves, with the long ears bent *in situ*. The G.E. Company of America are now using a grooved trolley wire of circular section, which has all the advantages of 8-shaped wire, without the disadvantage of readily making kinks which cause the trolley to jump. It is not good practice to make the top half of the bracket-hanger clamp serve the double purpose of supporting the hanger and guard-wire standard, for, if the trolley wire snapped, the whole bracket clamp would turn round, and might cause the guard wire to break or sag on to the trolley wire. Moreover, in straining up the guard wire, owing to the length of the leverage the bracket hangers themselves are pulled out of the vertical, thus causing a kink in the trolley wire. Where guard wire is used over very short distances, say between two or three poles, it should be earthed directly to the rails, otherwise, if it came into contact with the live wire the earth would not be good enough to knock out the station circuit-breakers, although sufficient current might be passing to make the guard wire red-hot and the ground round the pole dangerous. This has occurred more than once. Guard wires should be put up with a view to standing the same stresses as trolley wire. A convenient-sized wire to use is a 7/17 S.W.G. galvanised mild steel, breaking with a load of not less than 1,400 lbs., and an extension of 4 per cent. on 12 inches. A good test for galvanising consists in dipping a sample of the wire into a saturated solution of copper sulphate for one or two minutes, then drying it so that it is perfectly clean and repeating this process half a dozen times. If the galvanising is not perfect the iron will be dissolved and the copper precipitated in a spongy mass on the wire. After erection the guard wires should be rubbed down with vaseline, to protect the zinc against hydrochloric and sulphuric acids and sulphuretted hydrogen, traces of which are invariably present in towns. In place of guard wires a wooden strip supported by clips from the trolley wire itself has been used. The strip is made of canary wood, or preferably kauri pine, and the clips are placed at 3-feet centres, and soldered to the trolley wire. The strip should be thoroughly painted with P. and B. paint. Considerable trouble has arisen with the clips, owing to knocks from the trolley wheel causing them to come unsoldered. Where guard strip is employed a considerable factor of safety should be allowed in the trolley wire, as ice and snow may add enormously to the weight per unit length, and a far bigger surface is exposed to the wind. Guard wires have been practically abandoned in the States. The wires erected on the Buffalo-Niagara Falls transmission lines have been taken down, decreasing the number of short circuits, and with no bad results from lightning. Experience suggests the following points with regard to the erection of guard wires: (1) They

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[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

should be vertically over the trolley wire, and well anchored at frequent intervals. (2) They should not be used round curves where "pull-off" wires would be necessary, guard strip being far more suitable. (3) Stronger and more durable material should be employed, and greater care should be exercised in erection and examination. E. H. C.-H.

291. *Detector for Low Bearings.* **G. Bright.** (Elect. World and Engineer, 36. p. 188. Aug. 4, 1900.)—A large traction company, operating 300 cars, turned 50 cars into the repair shop between January 1 and April 15, 1900, on account of low bearings, which had allowed the armatures to rub on the lower pole-pieces, thereby destroying the insulation and damaging the teeth. One-third of these had to be entirely rewound. The author uses a detector to give warning of a low bearing before any damage is done. The device is simply a bent spring fixed to, but insulated from, the magnet casting. Before the armature can touch the pole-pieces its teeth will come into contact with the spring, thereby closing the circuit of a bank of lamps or other warning signal. E. H. C.-H.

292. *Wheel Flanges and Rail Grooves.* **W. G. Keagey.** (Tram. Rly. World, 9, pp. 362–364, Aug., 1900.)—The primary cause of the breaking of wheel flanges is the use of a girder rail with a narrow groove. The Manchester Corporation has recently secured official approval of an excellent rail section, having a tread 2 inches wide and a 1⅛-inch groove. With the 1-inch groove previously allowed sharp curves were impossible with long wheel bases, and the wheels rapidly cut away the sides of the grooves, sometimes leaving a dangerous cutting edge on the guard rail. The flanges must be deep enough to keep the wheels on the track, and thick enough to prevent chipping when obstacles are met in the groove. A ⅜-inch flange has been successfully used at Leeds on some worn rails where only half an inch depth of groove was left: ⅝-inch is found too deep a flange; ½-inch is the best standard. The objection to a deeper flange is its thinness and consequent weakness, necessitated by the restricted width of groove. One of the chief causes of breakage of flanges is the practice of increasing the gauge of track at curves without proportionately widening the rail grooves. A tread and flange well designed to suit their rails should make the flange last the full life of the wheels—*i.e.*, at least 1 to 1½ years. A pair of "Griffin" wheels on the Dublin United Tramways lasted nineteen months and ran 52,839 miles. E. H. C.-H.

293. *Heavy Track Construction in New Orleans.* (Street Rly. Journ. 16. pp. 428–430, June, 1900.)—The New Orleans and Carrollton Railroad Company has recently put down the heaviest electric road T-rails in the States. They are of the A.S.C.E. section, 5¾ inches high, and weigh 100 lbs. per yard. Owing to the spongy nature of the soil all the track is laid on a plank flooring. An excavation about 24 inches in depth and 10 feet wide was made for each track. The bottom of this trench was then laid with 1¼-inch creosoted long-leaf yellow pine planking. On this were placed 8 inches of broken stone of a size which would pass through a 1½-inch ring. On this stone were then placed 6 in. × 8 in. × 8 ft. creosoted yellow pine ties, sawn square, and spaced 24 inches centre to centre on straight track. Broken stone was carried up between the ties; gravel was then inserted to fill up the space up to the top of the ties, after which earth was filled in to the top of the head of the rail on the outside, and to the bottom of the head in the inside of the track. Standard

6-bolt fishplates are used. The rails are bonded with No. 0000 Standard concealed bonds, with cross-bonds at special work only. The joints are staggered and suspended. The special work is of the Lorain Steel Company's 9-inch girder "guarantee" type, joined to straight track by 100-lb. T-wing rails and cast-weld joints. E. H. C.-H.

294. *Tests of the Buffalo Street Railway Power Plant.* **R. C. Carpenter** and **H. J. Ryan.** (Street Rly. Journ. 16. pp. 646–649, Aug., 1900. From the Sibley Journal of Engineering.)—Power for the Buffalo tramways is obtained partly from their own steam plant and batteries and partly from the Niagara Falls. The Niagara Company have contracted for a continuous supply of 2,000-h.p., and the chief object of the battery is to utilise this power during light-load hours, as well as to help the generators at times of heavy load. The battery contains 272 cells of 3,000 ampere-hours capacity. The test was to determine the relative values of the three conditions of operation—(i) By steam, operating 10 units — viz., three 1,000-h.p. vertical cross-compound direct-coupled engines, six 500-h.p. vertical cross-compound belted engines, and one 250-h.p. horizontal cross-compound belted Ball engine. (ii) By Niagara Falls power operating four 500-h.p. rotary converters. (iii) By storage battery operating through a 210-kw. 70-volt booster; also to determine the efficiencies of boilers, engine, and electrical equipment. Ninety-six observers were required, and three twenty-four hour runs were made as follows: (*a*) Under normal conditions, *i.e.*, with full quota of Niagara power, with as many engines as the load required, and with battery in normal service. (*b*) Eliminating Niagara Falls power and using engines and battery only. (*c*) Eliminating the battery and using engines and Niagara power only. The boiler plant comprises sixteen Babcock and Wilcox boilers and two of the Scotch marine type, all fitted with Roney automatic stokers supplied with coal from a travelling car on an overhead track. The rated capacity of the boilers is 5,080 h.p. Full results of the boiler test are given. The average equivalent evaporation from and at 212° F. was 8·3 lbs. of water per lb. of dry coal. For the engines test 38 indicators were used and 7,344 cards taken. In the three runs the lbs. of steam per i.h.p. per hour (auxiliaries included) were, respectively, (*a*) 24·88, (*b*) 24·38, and (*c*) 25·71; the lbs. of coal per i.h.p. per hour were (*a*) 3·53, (*b*) 3·31, and (*c*) 3·64; the lbs. of water from and at 212° F. per e.h.p. per hour were (*a*) 34·1, (*b*) 33·5, and (*c*) 34·2; the lbs of dry coal per e.h.p. per hour were (*a*) 4·23, (*b*) 4·04, and (*c*) 4·17. The saving due to the use of the battery appears to be about 4 per cent. in coal, to which must be added a reduction in repairs to engines owing to steadier load.

E. H. C.-H.

295. *Stationary Batteries for Tramways.* **F. J. Stone.** (Street Rly. Journ. 16. pp. 868–869, Oct., 1900. Paper read before the New England Street Railway Club, Boston, Sept. 5.)—The author advocates the use of a battery of accumulators, either in a tramway generating station, or at some point on the line, and points out the recognised advantages of so doing. He mentions the installation of the Brooklyn Heights Railway Company, where a very heavy summer load is met, by running a battery mounted on cars to the end of a long feeder, and there leaving it connected up during the months of heavy load. G. H. B.

296. *Stationary Batteries for Tramways.* **P. W. Davis.** (Street Rly. Journ. 16. pp. 869–872; Discussion, pp. 872–873, Oct., 1900. Paper read before the New England Street Railway Club, Boston, Sept. 5.)—The author considers the case of a line 12 miles in length with a heavy grade at a distance of 8 miles, and supposes that the increase of traffic has rendered necessary some means of maintaining the pressure at the distant end of the line. He considers different solutions of this problem, and gives curves showing the fall of pressure along the line in each case; taking the capital expenditure into consideration, he concludes that the location of a battery at the grade is the best solution. Under the original conditions the voltage falls from 575 to 76 at the grade; on installing a battery, at a cost of $4,500, the pressure at this point is increased to 313 volts. To produce the same result by an additional feeder would cost $18,500, and by a booster and separate feeder $7,500. The author further discusses the use of batteries in rotary converter substations, and the use of boosters for charging the cells.

G. H. B.

297. *Railway Power Transmission.* **J. H. Armstrong.** (Street Rly. Journ. 16. pp. 889–892, Oct., 1900. Paper read before the New York State Street Railway Association, Sept., 1900.)—There are five methods of distributing power for railway work: (1) 500-volt direct-current throughout. (2) The operation of series-wound direct-current boosters in connection with 500-volt apparatus. (3) The use of three-wire distribution, using the track as a neutral. (4) Alternating current with step-down transformers and rotary converters. (5) Alternating current transmission with three-phase motors mounted on the cars.

The author points out the well-known advantages and disadvantages of the first three methods.

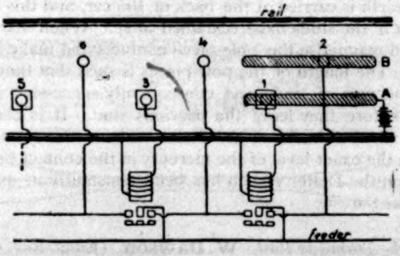
The fourth method, with alternating current, has the advantage that the energy can be transmitted over large areas at high voltage with consequent small copper investment and small loss, and at the same time ordinary direct-current traction equipment at 500 volts can be used on the cars. Step-down transformers must always be used where rotary converters are employed, as the voltage on the alternating side bears a fixed ratio to the voltage on the commutator (about 64 per cent.). Motor generator sets may receive line voltages direct, up to 10,000 volts, but the saving of step-down transformers is off-set by the extra cost of the motor generator. Modern 25-ton suburban cars running at 40 miles an hour require on an average about 100 kw., but may demand two or three times this amount when starting or on severe gradients.

In the fifth system, where three-phase current is used throughout, the trolley or third-rail voltage being no longer confined by the limitations of the direct-current commutator, can be raised to several thousand volts if necessary. Expensive third-rail construction can, in fact, be dispensed with, as at high voltage the current is so small that with the very heaviest traffic ordinary overhead construction is possible. The position of the step-down transformers along the line is determined by the relative cost, and the cost of trolley and copper for feeders between them. As they are in use only whilst a train is passing, the step-down transformers can be made of small thermal capacity, but of large momentary overload capacity, so that, their cost being small, they can be placed comparatively close together, keeping the line-drop low and increasing the efficiency of transmission.

E. K. S.

298. *Surface-contact System at Monaco.* (Street Rly. Journ. 16. pp. 361–362, May, 1900.)—The system installed at Monte Carlo by the French

Thomson-Houston Company several years ago has run most successfully. Last summer 2·8 miles were in operation. The track is laid with 72-lb. rails to metre gauge. The route is very hilly. One hill 400 metres long has a 9 per cent. rise in parts. The sharpest curve has 20 metres radius. Current is picked up by long shoes or skates under the car from contact blocks which are kept alive by section switches placed in manholes near the track. The contacts are in two rows between the rails, staggered, and each block is about 1 foot from the nearest rail. The blocks are mushroom-shaped on the surface, and are set into cast-iron boxes bolted to the ties. The pavement is of wood. One set of blocks is for carrying current to the car from the feeders. The other set is for connecting the first set with the feeders. When alive, the first set is at 550 volts, but the second set is at much lower potential. The feeders are carried in trenches at the side of the track. The section switches are of the three-pole type with carbon contacts against copper, and are actuated by electromagnets. The centre contact is connected with the feeder; each of the other two is connected to its neighbouring high-potential contact block, and also to one of the poles of the adjoining section switch. The low-potential contact blocks are connected through the magnets of the section switches to earth, as shown in the diagram. The magnetic blow-out, placed close to the contact points, blows out any arc which might be caused when the armature of the magnet in the section switches drops. The contact devices carried on the car are two in number, as shown in the diagram, and consist of skates long enough to span the distance between two adjoining contact blocks. They are connected to the truck by springs, so as to give a continuous pressure against the blocks. The contact blocks project about half an inch above the surface of the paving. The method of operation is as follows: Contact blocks 1, 3, and 5 are those of low potential, while 2, 4, and 6 are those of high potential. Assume that the car is stopping in the position shown in the diagram. To obtain a starting-current the motor-man closes a switch connecting a small storage battery between the skate A and the ground. This gives a current through contact block 1 to the ground, and raises the armature in the first section box, connecting contacts 2 and 4 with the feeder. The car then takes current from contact 2, through skate B, and as the car is moving from right to left it soon takes current from contact 4, which is also alive. The motors are not earthed directly, but are connected to the skate A, so that as soon as the car starts the current flows from the motors through contact 1 to the ground, making it possible to cut out the storage battery. When the car proceeds so that skate A covers contact block 3, the magnet of the latter is excited by the current from the motors, making contact blocks 6 and 8 alive, and when skate A has left contact block 1 it breaks the circuit through the first section box, making contact



block 2 dead. The contact blocks are about 3 metres apart. The Company has six cars in operation, running on a headway of ten minutes. The length of each trip is about fifteen minutes. Each car has room for twenty-four passengers inside and six on each platform, and is divided into two classes. The length of the body is 8 metres, and the cars are equipped with G.E.-53 motors and B-16 controllers. E. H. C.-H.

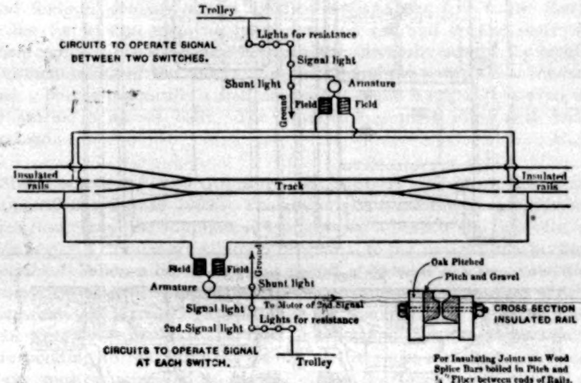
299. *Dolter's Surface-Contact System.* **E. Nelson-Uhry** and **J. Reyval.** (Écl. Électr. 24. pp. 216–221, Aug. 11, 1900.)—The car carries two electromagnets slung from the truck, the pole-pieces forming contacts which rub against studs in the centre of the track. The magnet windings are in series with the motors, between the controller and the pole-piece contact. The N. and S. poles are side by side, in positions corresponding to the two magnetically, but not electrically, insulated halves of the contact studs or discs. When the electromagnets come over a pair of studs the magnetic circuit passes through a hinged armature in a contact box below, this armature forming the short arm of a lever whose other end carries a carbon block, which, when the armature is attracted, makes contact with the feeder. After the car has passed, the carbon contacts separate by their own weight, aided by a spring. A safety trailing earth is carried at the back of the car, and this blows a fuse in the contact box if the studs have remained alive. When starting from rest, cells are used to magnetise the pole-piece contacts and make the first pair of contacts alive. The length of the pole-pieces is such that they are always in contact with one pair of studs, and consequently successive studs are made alive by them before they leave the previous stud. It is claimed that this system has not the drawbacks of the Diatto system, where satisfactory working depends on the exact level of the mercury in the contact box. Since May 30, 1900, a car on the Dolter system has been constantly in use on a line 750 metres long near Suresne. E. H. C.-H.

300. *Demerbe Tramway Rail.* **W. Dawson.** (Elect. Rev. 47. pp. 521–522, Sept. 28, 1900. Paper read before the Brit. Assoc.)—The Demerbe rail is, in section, an inverted trough with curved contour, forming on the upper surface a channel similar to that of the ordinary girder rail. The fishplate fits exactly inside the rail, and is secured to, and at the same time pressed into, the rail by two cotters, each passing through both sides of the rail and fishplate. The tie-bars are flat and set on edge; one side of the rail fits exactly into a notch in the tie-bar, while the other is secured in a wider notch by a wedge. The rail is completely filled by special tools with concrete, which becomes firmly attached to the rail, and forms a continuous and uniform support for it; and if the track be laid with a concrete foundation the rail becomes practically incorporated with it, and the two rails form one uniform structure. At Bradford 4 miles of 70-lb. Demerbe rail were laid end to end with a similar length of 105-lb. girder rail, with a view to comparing their relative advantages; the result, after six years' service, was greatly in favour of the Demerbe rail, especially as regards cost of maintenance. The costs, including laying the rails, were respectively 19s. 5·4d. per yard for the Demerbe, and 23s. 1·4d. for the girder rail. The author estimates the life of the Demerbe rail to be 25 per cent. longer than that of the girder rail. G. H. B.

301. *The Electric Railway Motor.* **J. Lundie.** (Street Rly. Journ. 16. pp. 779–783, Oct., 1900.)—The author first discusses acceleration and braking, pointing out the well-known advantages of rapid acceleration. He then

discusses the rating of motors, and proposes that the power rating of a railway motor on frequent intermittent load should be directly proportional to the average current input, independently of variations in current, except in so far as the current may be governed by the limitations of satisfactory commutation. A motor might be rated at 6,000 time-current units to operate between current limits of 100 and 250 amperes. This motor on continued intermittent service ought not to have a greater temperature rise than the one agreed upon, whether operating on 100 amperes 60 per cent. of the time, or 250 amperes 24 per cent. of the time. The author gives five curves showing temperature rise of a particular motor on different intermittent loads. R. B. R.

302. *Columbus Railway Company's Methods.* (Street Rly. Journ. 16. pp. 661–668, Sept., 1900.)—Some of the streets in Columbus, the capital of Ohio, are lighted from steel lattice arches spanning the streets, each carrying fifty 16-c.p. incandescent lamps. The Company own 98 miles of line radiating from the centre of the city, as well as an interurban railway from Columbus to Westerville, a distance of 15 miles. Owing to the gauge being 5 ft. 2 in., the bicycle truck is used under all double-truck cars.



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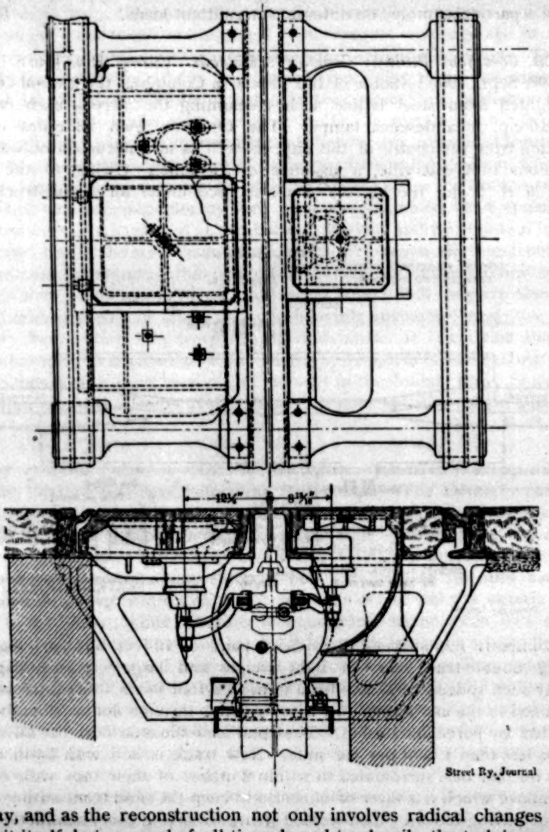
The Company has successfully spliced pairs of 16-feet box cars together, making double-truck cars of light weight and large carrying capacity. Twenty such spliced cars have been in use for four years. Great importance is attached to the car wiring; all wires passing through floors or timber are protected by porcelain bushes. The total maintenance cost for all rolling stock is less than 1 cent per car mile. New track is laid with 74-lb. 8-inch T-rails on oak ties, surrounded to within 2 inches of their tops with broken stone, above which is a layer of concrete to keep the sand from sifting down from the paving blocks. Cast-welded joints are giving every satisfaction. On the interurban line an interesting automatic block signal is used between turnouts. It consists of an ordinary signal arm operated by a connecting rod and crank on a countershaft driven by a Western Electric 16-inch fan motor. The signal is worked by the car-wheels passing on to and earthing an insulated rail to which one pole of the motor is connected (see Figure). The motor is shunted across a 50-volt lamp, so that there are only 50 volts between the insulated rail and earth ; in practice leakage reduces this to about 30 volts, which is claimed to be "too low to be noticed by any one coming into contact with the rail." E. H. C.-H.

303. *Changing from Cable Trams to Electric on Broadway, New York.* (Street Rly. Journ. 16. pp. 702–708, Sept., 1900.)—The reconstruction is being carried on without interfering with the operation of the cable cars, and as these cars run under a thirty-seconds headway during the greater portion of the day, and as the reconstruction not only involves radical changes in the conduit itself, but renewal of all tie-rods and track rails, the task is one of no small engineering difficulty. It is done by keeping the men at work as long as possible between bunches of three or four cars, and then having them suspend operations until these cars have passed, then beginning their work again quickly. The Figure shows a cross-section and plan of the Broadway conduit as adapted for electric traction ; the existing sheaves and grip are



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superimposed in light lines in their correct position. The insulators, brackets, and conductors will be installed at a later date through the handholes and grip-hatches without disturbing the pavement, but this will be a difficult matter. If they are placed in position while the cable is in use the grip will be apt to collide with the conductors and break the insulators. On the other hand, if cable operation is stopped during the long process of introducing the insulators and conductors, the financial loss owing to suspension of traffic would be considerable. In the conversion of the Third Avenue Railroad the insulators were mounted on rods so that they could be slid to the side of the conduit and equipped. When the Company was ready to make the change to electricity the cable was stopped, and all the insulators in a section were slid forward into position together, taking a much shorter time than if all the work of placing them in position had to be done when cable operation was suspended. On the other hand, the Capital Traction Company, of Washington, D.C., in altering its Pennsylvania Avenue cable line to electricity, ran horse cars during the interruption. E. H. C.-H.

304. *Gearing for Electric Motors.* **A. H. Gibbings.** (Cassier, 18. pp. 508–509, Oct., 1900.)—Various gears are described. The Twentieth Century Speed Reducer consists of two fixed rollers and one free roller operating together by friction upon an outer cast-iron rim and on the shaft of the electric motor. The difference between the circumference of the shaft and the circumference of the rollers gives the ratio of the reduction or increase of speed. This is practically a friction gear, but slip is impossible even if the gear works in an oil bath. The Humpage gear is illustrated but not described. R. B. R.

305. *Curves on Electric Railways.* **K. Sieber.** (Elektrotechn. Zeitschr. 21. pp. 863–864, Oct. 18, 1900.)—The author points out the great disadvantages which result from the adoption, in going round a bend in the line, of a curve consisting of a circular arc which is tangential to the straight-line portions of the track. When a car is running round a curve it has two velocities—a translational and a rotational one. If we now assume that a car which has been running along a straight portion of the track is made to swing round a circular arc tangential to the straight-line portion, then the angular velocity corresponding to the particular radius of the curve and the given speed of the car must be impressed on the car within the short distance equal to its length. The angular acceleration corresponding to this will be very great, and will cause an abnormally great side-pressure on the outer rail. In order to reduce the wear and tear due to this cause, as well as to ensure smooth running, the author recommends the adoption of intermediate or transition curves between the circular and the straight-line portions of the track, the shape of the curves being so chosen as to reduce the angular acceleration as much as possible. A. H.

306. *Electric Traction Practice in France.* **A. N. Connett.** (Street Rly. Journ. 16. pp. 761–774, Oct., 1900.)—Three types of rail are in use, viz.: (i) T-rail; (ii) Double or "Marsillon" type, consisting of two small T-rails mounted on a cast-iron chair. The metal in this type is badly distributed and in new work the type most used is (iii) the girder rail. Rail specifications are very long and rigorous. The carbon is seldom specified, but in its place is the "resistance in tension," which can now be got as high as 75 kilog. per sq. mm. The older joints are generally bad, but cast-welded joints are now being largely used with satisfaction, except on the light Marsillon rails, where a rigid cast-welded joint makes the track bumpy. All feeders are underground and almost invariably lead-covered and armoured. Junction boxes, but not wiped lead joints, are used. Draw-in systems are unknown; the cables are laid in trenches 28 inches deep and are surrounded with sand, on top of which is placed wire netting as a warning to future excavators.

An outline is given of the conditions imposed by the authorities on electric tramways, and the chief clauses in the concession given to the "penetrating lines" into Paris in March, 1899, are set forth as typical of those now enforced. The Government telephone and telegraph lines are elaborately protected: a new law on this subject is expected in the near future. All cars must be equipped with two braking systems, each capable of stopping a car in 20 metres on a 2 per cent. down-grade at 20 km. per hour without the use of sand. If trailers are used this trial must be made with an empty motor-car and loaded trailer. The power brake must be capable of application from the rear platform independently of the motor-man; this condition excludes electric brakes and practically necessitates air brakes, which are of three satisfactory types: (i) Stored air with charging stations at intervals, (ii) electric motor-driven compressors on the cars, (iii) axle-driven compressors. The first type is the simplest, but requires room for the reservoirs. The second is used only on the "Metropolitan" (underground). The third is chiefly used on new lines and promises well. The regulations as to brakes on trailers are so stringent that the author anticipates their replacement by long single-deck double-truck cars with central platform. Power-station practice is of no special interest.

The new lines round Nice are the first French example of a large system operated by three-phase transmission and substations from distant hydraulic power. The "Potter" surface-contact system in Monaco has proved workable for two years, and could be safely installed under similar climatic conditions. The Paris conduit lines are efficient and practical and will extend greatly. The "Diatto" surface-contact system has been adopted, on the strength of results on 2 miles of trial line, for 80 km. of the Paris "penetrating" lines. The line joining the Pont d'Austerlitz and Quai d'Orsay stations of the Orleans Railway is very successfully operated by electric locomotives, which take about fifty trains a day each way. E. H. C.-H.

307. *Brakes and Signals for Behr's High-speed Railway.* **F. J. Behr.** (Elect. Rev. 47. p. 482; Discussion pp. 482–483, Sept. 24, 1900. Paper read before the British Association.)—The rapidity with which a train can be stopped is limited by the discomfort occasioned to passengers. For a train travelling at 60 miles an hour this limit is reached if it be stopped in 360 yards, and for a train travelling at 110 miles an hour, in 500 yards. Brakes enabling this to be done are useful in avoiding collisions with another train, or other object visible to the driver at a distance, but no brake could be applied which would avoid small obstacles placed on the rails, or a broken rail, as the driver cannot see such obstacles until he is practically upon them.

On the proposed Manchester and Liverpool express railway, though it would be possible, in an emergency, to brake the train in less than 500 yards, the system is so designed as to render it impossible that such a case of emergency should occur. As on the proposed line there are no level-crossings or turn-outs, the only reason for stopping the train before the station would be the breakdown of the preceding train. Such a breakdown would be made known by automatic signals for a distance of over 4 miles behind. For signalling purposes the line is divided into eight sections of 4·3 miles each, and a train, on entering each section, puts up a danger signal at that point, which danger signals are lowered only when the train enters the second section ahead, *i.e.*, at a distance of 8·6 miles. Two trains can never therefore be within 4·3 miles of one another—a condition which renders superfluous any emergency brake. Should a train pass a danger signal this is shown in the driver's cabin, so as to be visible in case of fog. G. H. B.

308. *Behr's High-speed Railway.* **W. H. Preece.** (Elect. Rev. 47. p. 482, Sept. 21, 1900. Paper read before the British Association.)—The monorail system of high-speed railway, projected by Behr for passenger traffic between Manchester and Liverpool, was first designed by Lartigue in 1882. A line between Listowel and Ballybunion in Co. Kerry was engineered by Behr and opened in 1888. The line is 9¼ miles long, with one intermediate station, and is worked by steam. The cost was £3,060 per mile. Several breakdowns have occurred in the rolling stock, but none in the line, and during twelve years' work no renewals of plant have been required.

The Manchester and Liverpool express will be more massively built ; the generating station will be at Warrington, at the centre of the line ; from this, power will be transmitted at 10,000 volts to substations at intervals of 4 miles, where the pressure will be reduced to 1,000 volts. The train will consist of one coach weighing 45 tons and seating 64 passengers ; the headway will be 10 minutes, and the speed 110 miles an hour. To reach this speed in 110 seconds, 1,600 h.p. will be required, and to maintain it on the level, 500 h.p. G. H. B.

309. *Meynier and Legros Electric Automobile.* **A. Soulier.** (Ind. Élect. 9. pp. 379–382, Sept. 10, 1900.)—The author describes an electric car in which the special feature is the motor. This has two independent ring armatures, revolving round an internal fixed field coil. The armatures are provided with radial commutators and are mounted on a divided shaft from which the rear road wheels are driven by single reduction spur gears. The usual form of differential gearing is thus dispensed with. Points claimed for this form of motor are very small losses due to magnetic leakage, and ability to dissipate rapidly the heat generated by the current, owing to the angular velocity of the armature being great, although the revolutions per minute may be comparatively small. The battery consists of 48 Fulmen cells each with 17 plates ; it is divided into two parts, one being placed under a sort of bonnet in the front of the body, while the remaining cells are stored below the seats and are accessible from the back. The two sets are ordinarily in series, but for the slowest of the four forward speeds they are in parallel. The whole of the mechanism is mounted upon a rectangular channel steel underframe. Plan and elevation drawings of the car are given, which show clearly the distribution of the various parts. Steering is by a hand-wheel, which controls the pivoted axles of the front wheels through a spur gear, and a novel combination of connecting links, shown clearly in the plan view. C. R. D'E.

310. *Siemens and Halske Electric Tram-Omnibus.* (Automotor Journal, 4. pp. 600–601, Sept. 1900.)—The vehicle described is constructed to carry eighteen persons, and is intended for use in connection with an electric tramway system. It is a four-wheel single-deck car carrying a storage battery of 200 cells which supply current to two motors geared independently to the rear road wheels.

It is intended that in crowded parts of towns where trams cannot be used, the electric car shall run as an independent motor vehicle; but on reaching an available tram line in the less-crowded parts the car is run by the trolley, and the cells charged, the idea being an extension of the "mixed system." In order to guide the car on the track and to give the necessary earth, a frame carrying two wheels of the gauge of the tram line is lowered when the line is reached. The vehicle illustrated (photograph) is designed to have an independent radius of action of about 20 km., and weighs, fully loaded, 6 tons. C. R. D'E.

311. *Lindstrom Electric Motor Cars.* (Automotor Journal, 4. pp. 559–561, Aug., 1900.)—A form of electric vehicle is described in which two independent motors are employed, driving the road wheels through single-reduction gear. The framework of the car is a tubular structure in which the members are specially arranged to allow of flexibility of movement between the front and rear axles in their vertical planes, and at the same time to preserve the parallelism of the axles and a rigid distance between the vertical planes in which they lie. The motors are spring-hung at one end and at the other are pivoted about the rear axle, so that each forms the radius bar for its own gear. Special forms of band-brakes are also described, reference being made to the British Patent No. 4619 of 1900. A feature is made in these cars of using pressures of from 104 to 120 volts instead of the pressure of 80 volts at which the motors for most electric vehicles are worked. The Hewitt-Lindstrom Company of Chicago construct, amongst other vehicles, one guaranteed to carry eighteen persons, 56 miles on one charge at a maximum speed of 9 miles per hour. This car weighs 2·5 tons, has two 4·5-h.p. motors, and 60 cells of 19-kw. capacity at 25 amperes. C. R. D'E.

312. *Hub Electric Automobiles.* (Electrician, 46. p. 19, Oct. 26, 1900.)—A novel type of American electric automobile is described, in which the whole of the propelling mechanism, *i.e.*, motors and gearing, is enclosed in the hubs of the driving wheels. In the two-seated car the rear wheels are driven, while in the four-seated car all four wheels have motor hubs. Each motor hub consists of a four-pole field magnet, which forms the hub of the wheel, and into the exterior of which wooden spokes are driven. Within the field there revolves a drum armature free upon the end of the fixed axle. On the outer extremity of the armature sleeve is the commutator, while at the inner end is a spur wheel which drives an internal toothed ring on the hub through a pinion mounted on a fixed pin. The ratio of gearing thus obtained is 5 to 1. In the larger car a ratio of 12 to 1 is similarly obtained. Suitable rubbing contacts convey currents from a 44-cell battery to the motors, which are always in parallel, the cells being in four groups, which may be connected in series or in parallel by means of a controller. A good sectional drawing of the motor wheel is given. C. R. D'E.

313. *Mildé Electric Carriage.* **A. Delasalle.** (Locomotion Automobile, 7. pp. 610–613, Sept. 20, 1900.)—The special feature in this design is the two-wheel motor tractor, which may be combined with any form of carriage body, and which replaces the ordinary steering wheels and fore-carriage. On it are all the principal mechanical parts—viz., motor, storage battery, and transmission gear, the whole being pivoted on a central pin, which, together with a suitable guiding sector, forms the connection between the carriage and the tractor. Steering is effected by turning the tractor about this pin, the operation being controlled from a hand wheel on a vertical spindle. This is connected by a pitch-chain gear to a short spindle having a spur pinion which gears with the teeth cut on the guiding sector of the tractor. The storage battery is carried in a box suspended below the axle of the tractor in such a manner that it can be easily detached for recharging. The motor has two independent armatures revolving in a common field, the ordinary differential gear being suppressed. The road wheels are driven direct from the ends of the armature shafts by single-reduction spur gear. Two photographs of complete carriages, and a plan and elevation of the tractor are given.

C. R. D'E.

ELECTRIC LAMPS AND LIGHTING.

314. *Efficiency of Incandescent Lamps.* **G. Weissmann.** (Écl. Électr. 24. pp. 356–360, Sept. 1, 1900. Paper read before the International Electrical Congress at Paris.)—The author gives figures showing that the practical efficiency of incandescent lamps varies from 3·5 watts per candle for a 100-volt 32-c.p. lamp, to 5 watts for a 5-c.p. lamp, while for 200-volt lamps the efficiency varies from 4 to 5 watts per candle. He quotes Blondel and Weber to show that thick filaments give a higher efficiency than thin ones, and are less sensitive to variations of pressure. Lamps of 16 c.p. at 22 volts were constructed by the author to give an efficiency of 1·67 watts per candle, and, after burning 200 hours, 1·93 watts per candle. He therefore proposes a system of internal wiring where a small transformer is employed for each lamp, or group of lamps, to reduce the pressure to about 20 volts. Such transformers can be made small enough to be concealed in the base of the lamp fitting, giving efficiencies of 85 to 96 per cent. The author claims an economy of about 45 per cent. in running lamps on this system.

G. H. B.

315. *New Incandescent Lamp.* (Scientific American, 83. p. 213, Oct. 6, 1900.)—At the Paris Exhibition there was shown a new process of glow lamp manufacture called the Malignani process, in which the vacuum is obtained in the bulb by the absorption of the gases by certain chemical substances, red phosphorus being generally used. Red phosphorus, formed into a somewhat liquid paste, is introduced by means of a piece of cotton on a wire into the tube by which the bulb is exhausted, and the walls of the tube are coated with the paste. A vacuum of one millimetre is first obtained by an air pump. Hydrocarbon gases are then introduced into the bulb; the pump is operated for half a minute, while a current is sent through the filament to bring it to dull redness. When the vacuum has been made as nearly complete as possible by the air pump, a stronger current is sent through the filament, and the outside of the bulb is heated by a small gas furnace placed below it to remove all moisture. When the vacuum has reached a certain point a light blue discharge appears at the positive pole, and eventually fills nearly the whole bulb; at this point the lamp is sealed off below the connecting tube. The red phosphorus on the walls of the tube is then heated, and it absorbs the remaining portion of the gases; at this point the discharge appears to fill the whole of the lamp. Upon heating the lamp for a few moments the discharge disappears, and the vacuum is complete. The glass tube is then sealed off and removed from the bulb.

The advantages claimed for this method are that the vacuum is better, the operation is more rapid, and it does away with the inconvenience of using mercury pumps.

E. C. R.

316. *Rating of Incandescent Lamps.* **A. J. Rowland.** (Frank. Inst., Journ. 150. pp. 241–272, Oct., 1900.)—The author emphasises the importance of exact knowledge of the candle-power of glow lamps, and states that, as lamps are usually installed, the most useful part of the light is that thrown out by the lower hemisphere towards the tip. Examining various common types, the author finds that, when giving 16 c.p. at right angles to the axis, a lamp with U-shaped filament gives only 5 or 6 c.p. along the axis towards the tip; with single-curl filament, 7 to 8 c.p.; with double curl, about 11 c.p. The last-mentioned is therefore the most effective; it is best made without a sealing-off tip at the end of the bulb. Diagrams are given showing the distribution of light with the various shapes of filament; the double U filament gives the most uniform distribution, but the author maintains that most of the light is wanted under the lamp, in which case the double-curl filament is the best. A large number of curves representing the horizontal and vertical distribution of candle-power about the various types of lamp are reproduced, and discussed in detail. The author next deals with the rating of lamps, and points out that the ordinary methods are very incomplete. As a complete determination of the mean spherical candle-power in every case is out of the question, the National Electric Light Convention has recommended that the candle-power be tested in a direction inclined at an angle of 45° with the axis of the lamp while it is rotating at 200 to 250 revolutions per minute. A number of comparative data showing the results obtained by various methods of rating are given below:—

Candle-Power Taken.	Candle-Power.				
	Single U-shaped Filament.	Single Curl Filament.	Long Curl Anchored Filament.	Double Filament.	Double Curl Filament.
(*a*) At 180 revs. with axis vertical .	16	16	16	16	16
(*b*) Mean horizontal (average of 12 readings)	15·8	16·2	16·6	16·0	15·72
(*c*) Mean horizontal (from plotted values)	16·0	16·7	16·7	16·1	15·6
(*d*) Mean spherical (standard method)	12·7	13·5	13·75	13·2	13·8
(*e*) Mean with axis at 45°	10·5	12·0	11·7	12·0	14·0
(*f*) Mean hemispherical	14·3	14·5	14·6	14·0	14·5
(*g*) Mean within 30° from tip	8·7	10·3	8·7	7·9	10·9
(*h*) From the tip	5·7	8·35	7·05	4·8	10·1

The author advocates the rating of lamps by the candle-power along the axis (line *h*); the measurement would be independent of the position of the filament, and rotation would not be necessary. Tables of efficiency referred to the various ratings given above, and of cost of energy per 16-c.p. lamp per 500 hours, are given and discussed; and the candle-power diagram (in a vertical plane) of a new form of filament giving large axial c.p. is reproduced. This filament, taking 61·6 watts at 116·3 volts, had a mean horizontal c.p. of 16·6; mean spherical c.p., 16·1; mean with axis at 45°, 16·5 c.p.; mean hemispherical c.p., 16·6; axial c.p., 15. The efficiency was 3·72 watts per c.p. (mean horizontal). The filament is of the double-curl type, flattened axially, and the bulb is also flattened.

In the discussion, **W. C. L. Eglin** exhibited a reflector lamp, and said that the horizontal light falling on the walls was important in illumination. An appendix by **A. J. Rowland** compared the reflector type of lamp with those considered in the paper, and pointed out its limitations. A. H. A.

317. *Series System for Incandescent Street Lamps.* **A. B. Proal.** (Elect. World and Engineer, 36. pp. 327–329, Sept. 1, 1900.)—At each point there are two lamps, one being in the series circuit and the other in parallel across the terminals but having a paper spark-gap. If the first lamp burns out or is broken the spark-gap breaks down owing to the rise in voltage, and the second lamp is thus put in circuit. In case the second lamp also burns out before an inspector's visit, a second spark-gap breaks down and cuts out the lamp. This second lamp has one terminal connected to a metal cylinder over which passes a strip of paper wound on two drums; resting on the paper there are two contact springs joined to the two main terminals, these springs forming with the metal cylinder the spark-gaps referred to.

It has been found by former experience that much trouble in high-tension work is caused by iron in contact with porcelain, as rust forms and is deposited on the porcelain, thus leading to large leakage and subsequent burn-outs. Copper and brass are therefore used in such places.

The system has been in operation for a year, and works perfectly.

It is stated that in series systems employing inductive shunts across the lamps the energy spent in the shunts amounts to 16 per cent. of the total.

W. H. E.

318. *Charging for Electrical Energy.* **E. de Fodor.** (Écl. Électr. 24. pp. 481–484, Sept. 15, 1900. Paper read before the International Electrical Congress at Paris.)—In order to encourage the demand for electricity during the summer months the author proposes to offer rebates varying inversely as the demand. The average number of hours of use per lamp per annum at Budapest is 440, divided as follows:—

Jan., 60	April, 29	July, 10	Oct., 50
Feb., 50	May, 19	Aug., 14	Nov., 64
March, 36	June, 12	Sept., 29	Dec., 67

These months are divided into three classes, according to the demand, and all energy consumed in any one month in excess of the corresponding mean value for that month is paid for under rebates as follows:—

October to February, 20 per cent.;
March to May, and September, 40 per cent.;
June to August, 60 per cent.

No demand indicator is required, the rebates being based upon the number of lamps installed on a consumer's premises. A. H. A.

REFERENCE.

319. *Joel Electric Car.* (Automotor Journal, 5. pp. 31–35, Oct., 1900.)—Description of the latest form of car described in Abstract No. 1295 (1899).

TELEGRAPHY AND TELEPHONY.

320. *The Dynamo and Storage Battery in Telegraph Offices.* **W. J. Camp.** (Canad. Elect. News, 10. pp. 170–171, Sept., 1900. Paper read before the Canadian Electrical Association at Kingston, Ont., Aug., 1900.)—Since 1880 primary batteries have been abolished in many large towns in America and Canada in favour of the dynamo and accumulators for telegraph purposes, both for single, duplex, and quadruplex. In some cases the dynamo is used without storage. For double current two dynamos may be used with opposite poles to bus-bars and to earth. Resistances are interposed in the several time circuits to equalise the currents going out, or else dynamos of varying voltages to suit the various circuits are employed. One form of resistance consists of German-silver wire wound on thin tubes, heat being thus carried off. Local circuits are also operated in multiple from a dynamo giving, say, 6 volts. Sometimes the dynamos are operated from a common shaft driven by an electric motor or other power, but the plan most generally adopted is to use motor generators, each machine working independently. For security of working, spare leads are run to different power stations, and spare machines are also in readiness. Transformers are employed where necessary to reduce the pressure where the current is taken from street railways or town mains. The writer states that the working of the lines has been much improved and a great economy effected. Diagrams and descriptions of joining up for duplex and quadruplex are given.

E. O. W.

321. *Pollak-Virag Telegraph.* **C. H. Garland.** (Elect. Rev. 47. pp. 628–633, Oct. 19; and 651–652, Oct. 26, 1900.)—The first form was a specially constructed telephone with optical and photographic attachments to register the vibrations of a diaphragm thrown into motion by currents following in very rapid succession. [Abstract No. 433 (1900).] It was demonstrated that the marks registered varied in character with the direction of the current, and also with the strength and duration of the current. The impression of the light-ray upon the sensitised paper could thus be elongated either in a vertical or a horizontal direction. But the curves of letters written with a pen are not fully produced by this method, the parts following only in horizontal sequence. Two telephones are now employed, each having a fine rod projecting from the centre of its disc and connected with the mirror which is to reflect the light upon the sensitised strip. The mirror is magnetically attached to three points, to one of which it is fixed, but about the other two it is movable. When the telephones are acted upon by suitable currents the mirror may be caused to describe movements which trace written characters upon the strip.

A metallic circuit is required for one of the two telephones, the other being interposed between the first and the earth. The perforations on the sending-tape are divided into two series, of which one sends the vertical components of the letters of the alphabet, whilst the other series furnishes the horizontal components, the telephone in the metallic circuit being concerned with the former and that in the earthed circuit with the latter. The roller over which the tape passes has five separate metallic sectors, over which perforations in five different lines on the tape pass, and the necessary contacts are made by five brushes bearing on the upper surface of the tape. The perforations differ in size, and being also different in position it will be readily understood that currents of varying strength, direction, and duration can be sent to line by a proper arrangement of the perforations. Three sectors of the roller communicate with the metallic circuit only and two with the earthed circuit, and the little rods of the telephone discs are brought into play accordingly.

The disturbances due to the proper or self-vibrations of the telephone membranes are overcome by shunting each telephone by a condenser. Induction coils are also used in shunt with the sending-contacts to eliminate or correct induction disturbances. The sensitised paper after being exposed to the spot of light passes downwards through an automatic fixing and developing apparatus, from which the message emerges ready for use. It is stated that six thousand ten-word messages per hour can be sent with the Pollak-Virag apparatus. The trial made over a metallic loop of 400 kilometres in length at Buda-Pesth, having a resistance of 2,000 ohms, showed that one thousand words per minute could be transmitted with perfect legibility and accuracy. E. O. W

322. *Key-board for the Hughes Printing Telegraph.* **G. Conradt.** (Elektrotechn. Zeitschr. 21. pp. 773–775, Sept. 13, 1900.)—Since the keys which may be depressed during one revolution of the chariot must be separated from each other by at least four keys, and since there are twenty-eight keys on the key-board, it is only possible, under the most favourable circumstances, to print five characters in each revolution. The greater the number of keys that can be depressed up to this limit the greater is the capacity of the instrument. Instead of arranging the keys in alphabetical order as heretofore, the keys are arranged as follows :—

1		2		,		.		;	:		3		4		5		!		,		"		˜		6		7		8
×		ä		ö		ü		e	a		o		z		v		p		c		i		u		g		f		b
	&		§		℔		pf.			/		)		(		–		0		9		%		=		+		?	
	ss		w		q		j			t		s		r		y		k		l		n		m		h		d	

This arrangement is based on a study of the sequence of the letters in the English, French, and German languages, two pairs of additional keys being added. By this means the capacity of the instrument can be increased 15·7 per cent. C. K. F.

323. *Ritchie's Telautograph.* (Electrician, 46. pp. 115–118, Nov. 16, 1900.)—In this system the transmitter consists of two independent quadrantal rheostats, over which move arms connected by links to the pen. Each of these rheostats has a total resistance of 7,000 ohms divided into 496 steps. The receiver comprises two large d'Arsonval galvanometer-movements, with strong controlling springs. The spindles bearing the moving coils of these movements are connected to a link motion corresponding to that of the transmitter part of the instrument, and move a pen over a similar piece of paper. There are two lines with earth connections, each of which, during the writing, includes a 24-volt secondary battery, a rheostat at the transmitting end and a moving coil at the receiving end. The instrument at each end comprises a transmitter and a receiver, and a switch is provided which cuts off the receiving part of the home instrument and connects up the transmitting portion and also controls the feeding of the paper. After traversing the moving coil on its way to the distant battery, the current passes on either side through a relay. These relays are so adjusted that the weakest current just suffices to cause their armatures to be attracted. When the current is momentarily interrupted by a further movement of the lever of the paper-shifting and starting switch, one relay drops back. This causes the current normally flowing through the magnet, controlling the paper-shifting mechanism, to be momentarily interrupted, and the release and re-attraction of the armature of this magnet causes the paper to be moved on by a mechanical grip. The other relay is used for signalling. In order to enable the pen at the receiver to be lifted from and returned to the paper with the pen at the transmitter, a bar is provided beneath the receiver pen, this bar being normally raised by a magnet in a local circuit. The pressure of the pencil on the platen at the transmitter effects the closure of the primary circuit of a small induction coil, of which the secondary transmits a vibratory current to line through a condenser ; this current energises a relay at the receiving end which breaks the circuit of the magnet controlling the pen-lifting bar at the receiver, and so allows the pen to return to the paper. Details are given of the signalling devices, which comprise telephones. The paper is illustrated by photographs and diagrams. C. K. F.

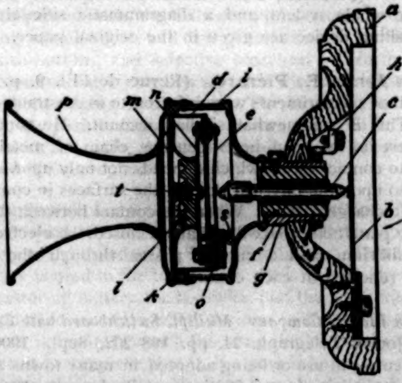
324. *Erratic Currents on Submarine Cables under Repair.* **H. G. Barwell.** (Electrician, 45. pp. 816–817, Sept. 21, 1900.)—These are noticeable by kicks on the galvanometer and intermittent buzzing of a telephone connected between the core of the picked-up end and the sea. They are explained as being due to small changes in the capacity of the cable caused by variation of the resistance of the contact between the respective sheathing wires at a splice, these variations being due to varying strains. If the depth of water is known, and the first indication of the splice being disturbed is noted on the telephone, an approximate idea of its distance from the ship may be obtained. M. O'G.

325. *Telephone Exchange at Munich.* (Elektrotechn. Zeitschr. 21. pp. 714–720, Aug. 23 ; 735–740, Aug. 30 ; and 755–760, Sept. 6, 1900.)—The main feature of this new exchange, which is designed for 10,800 lines with complete metallic circuits, consists in that the drop indicators are replaced by small incandescent lamps. By this means an attendant can serve 100 lines instead of 80. A full description, illustrated by working drawings, diagrams, and photographs, is given of the whole of the plant. C. K. F.

326. *Breguet's Telephonic Transmitter.* **L. Montillot.** (Électricien, 20. pp. 164–166, Sept. 15, 1900.)—This arrangement has a d'Arsonval microphone ; four carbon pencils are vertically supported in pairs between fixed horizontal carbons, of which the upper is common to the four, while below there are two blocks, one for each pair of uprights. These latter are partly covered by sleeves of sheet iron, and behind them is a magnet regulator movable by an adjusting screw, which acts upon the carbons through the medium of the iron sleeves, and presumably limits or amplifies their movements according to the adjustment. The necessary contact springs, contact-maker, microphone, and induction coil are all arranged symmetrically in one plane upon an upright board, and the receiver hook and lever, in place of carrying contact springs, is caused to move up and down a rod moving in guides with a cross-piece which engages with the springs. When the telephone is on the hook the rod is vertically at its highest point, in the middle of the board, and presents means for allowing the press button to be used. The arrangement is employed by the French Government. E. O. W.

327. *Microphone Transmitter.* **J. Baumann.** (Zeitschr. Elektrotechn., Wien, 18. pp. 479–481, Sept. 30, 1900.)—This telephone transmitter is specially designed for long-distance working, and is the type adopted in the German Post Office.

Referring to the drawing, *p* is the mouthpiece conducting the sound waves to the circular carbon plate *m*, which is protected by a grid. Against the middle of the disc *m* rests a woollen pad *t*, secured to the centre of the grooved carbon disc *l*, and serving to damp the vibrations of the disc *m*. The disc *l* is surrounded by a ring of fabric, the upper edge of which is fringed out, and the threads forming the fringe are cemented round the edge of the disc *m*, so as to form a space between *m* and *l* to receive the granular carbon. The disc *l* is mounted on a flat spring *n*, which can be adjusted by means of a screw *s*, so as to regulate the pressure of the granular carbon against the plate *m*. These parts of the instrument are contained in a metal casing *i*, which surrounds the edge of the plate *m*, and conducts the current to it. The current enters at the screw *h*, and passes through the tube *g* to the casing *i*. From the granular carbon the current passes through the plate *l*, the spring *n*, spring *e* and pin *c* to the spring *b*. Platinum contacts are provided on the pin *c* and springs *b* and *e*. This arrangement of contacts is designed to permit the easy removal of the microphone, which can be taken out directly on opening the casing *i*. The position of the granular carbon can be altered by turning the tube *g* in the base *a*. C. K. F.



328. *Leopolder's System of Bell-signalling and Telephonic Communication for Railways.* **A. Prasch.** (Zeitschr. Elektrotechn., Wien, 18. pp. 445–448, Sept. 9, 1900.)—In this system, which is used on the Austrian State Railways, there are sets of signalling and telephonic apparatus at each pair of adjacent stations, and at the intermediate signal-boxes. The stations are each provided with bells sensitive to alternate currents only, arranged in series with bells sensitive to direct currents only; and the signal-boxes are provided with bells sensitive to alternate currents only; whilst both the stations and signal-boxes are fitted with small magneto-machines which are capable of supplying either alternate or direct currents as desired, the station machines normally giving alternate currents, and the signal-box machines normally giving direct currents, the change from alternate to direct, or *vice versâ*, being effected by depressing a key. A switch is provided at each station whereby the magneto-machine or the telephonic apparatus can be connected to either of the adjacent signal-boxes or stations. By this means each station can ring the signal bells both at another station and at a signal-box ; or, on depressing the key, can ring up the station only by means of a direct current.

There is also described a device which automatically gives a definite series of signals, and consists of a clockwork train driven by a weight and adapted to drive the magneto-machine. This main train can be controlled by auxiliary trains which each correspond to a definite group of signals and keep the line-circuit closed whilst these signals are given, the number of these auxiliary trains corresponding to that of the lines to be served. A diagram of connections of the whole system, and a diagrammatic side elevation of the automatic signalling device are given in the original paper. C. K. F.

329. *Contact Force.* **E. Piérard.** (Revue de l'Él. 9. p. 116, Aug. 15, 1900.)—The author's experiments were referred to in Abstracts Nos. 1226 and 1971 (1900). This is a somewhat similar account. He concludes that in his circuits there is an open heterogeneous chain of metals at different potentials due to contact force (which depends not only upon chemical composition, but also upon the physical state of the surfaces in contact), and that a certain electric charge results. When the contact between the point of the vibrator and the plate takes place the chain is closed, the electromotive forces come into equilibrium, and a current passes through the circuit. The electric flow is renewed at each contact. E. O. W.

330. *Western Electric Company's Multiple Switchboard with Central Battery.* **J. Anizan.** (Journ. Télégraph. 24. pp. 198–202, Sept., 1900.)—This, the latest development, is in use or being adopted in many towns in Europe for boards of varying capacity, from 1,200 jacks at Bucharest to 13,000 at Vienna ; the London Post Office will have one of 5,000 lines. In America 100,000 lines were served on this system this year, and the number will soon be 300,000. The proposed London system was referred to in Abstract No. 1,765 (1900). A lamp lights up over the subscriber's jack when he takes his telephone off the hook ; it is extinguished when the operator plugs in. If while getting communication the caller goes away and replaces his telephone another lamp lights up behind the cord of his plug. Each cord has one of these lamps ("signals of control") in addition to the lamp over the individual jack ("signal of call"). When two subscribers are conversing the "cord" lamps are extinguished, so that the operator is aware that they must not be disturbed. When the telephones are restored the "cord" lamps light up and the plugs are removed by the operator. These lamps are all worked by relays, and of course take the place of annunciators. Visual signals made with painted shutters worked electromagnetically can be used instead of lamps. In the latest arrangements the subscriber's telephone receiver is not in the direct-line circuit as formerly with the secondary of the induction coil, but makes with one winding of a transformer, the other winding of which is to line, a shunt to the polarised bell. The microphone, also shunted, is in series with the parallel coils of this transformer, the current being of course derived from the central battery at the exchange. E. O. W.

331. *Intercommunicating Telephone System.* **W. S. Henry.** (Amer. Electn. 12. p. 448, Sept., 1900.)—The author describes with diagrams improved means by which, without a central exchange, subscribers can, upon one circuit, selectively communicate with each other. [See Abstract No. 2525 (1900).] Each station has a selective switch; there is a separate wire for each station, connected, however, to the appropriate stud in all the switches. There is also a common return wire, and also a battery wire, where one ringing battery only is provided for the whole circuit. To prevent inconvenience by reason of the user leaving the selective switch off the home stud the vibrating bell is permanently connected to the home button and to the common return wire through the rest contact and lever of the telephone, so that the bell must ring when any other station calls the station in question. The person called up would then, in order to speak, have to properly adjust his own switch. If magneto-generators and polarised bells are used, the battery wire is dispensed with, the bells are put in circuit in the same way as in the preceding arrangement, and the generators are put in between the home studs, push-buttons, and selective switches. A further method dispenses with a common battery and its separate wire, and employs a battery in each station for both ringing and talking. The battery is in circuit with the selective switch, the push-button, and the return wire. It is also, for speaking purposes, in circuit with the pivoted end of the telephone lever, the primary coil, and the microphone. E. O. W.

332. *Multiple Switchboard for St. Etienne.* **L. Montillot.** (Électricien, 20. pp. 65–72, Aug. 4; and 100–106, Aug. 18, 1900.)—A full description with useful diagrams of a board exhibited at the Paris Exhibition. There are few novel features. A relay is used in the test circuit. It is in circuit with the tips of the plugs, the restoring battery, the test wire, and the test contacts of the jack. When it is required to ascertain whether a line is free or engaged the tip of the plug as usual is made to touch the brass rim of the jack, and the relay closes if the circuit is complete, that is, if a plug is anywhere in a jack of this line. When the relay closes a local battery is put in circuit with the operator's receiver and a click is heard. If there is no click the line is free and can be joined over. The relay in this arrangement is in duplicate, so that if one is not working properly, the second can be brought into circuit by operating a special "changing key." The "test" circuit is absolutely independent of the line circuit.

The cables behind the jacks are made up flat, in thicknesses of 6 mm. or under, corresponding to the handles of jacks, and each row is on a lath or rod capable of being lifted up to allow of examination of the cable next below. They are said to be more convenient than round cables. E. O. W.

333. *Telegraphone.* **E. Ruhmer.** (Phys. Zeitschr. 2. pp. 1–3, Oct. 6, 1900.)—The principle of the telegraphone can be demonstrated by comparatively simple apparatus. An endless band of thin steel is stretched between four brass rollers set at the four corners of a long rectangle. It passes twice round the top pair of rollers and then twice round the lower pair, so that there are two vertical lengths of band, one at each end of the rectangle. The "speaking" apparatus consists of an electromagnet whose poles are fixed near to the band at one or other of the vertical stretches. A second electromagnet, connected in series with a telephone, is placed with its poles near to the band at the second vertical stretch of the steel band. The "speaking" electromagnet is connected in series with the secondary windings of a transformer, the primary of which is connected with a microphone and accumulator. The electromagnets are each constructed of two cylindrical cores, with two ends opposed, in the same straight line; the opposed ends are fixed just out of contact with the steel band, and transversely to it. The cores are 20 mm. long and 1 mm. diameter, made of best Swedish iron. The "speaking" electromagnet is wound with 2,000 turns of 0·1 mm. copper wire. The second electromagnet is wound with finer wire, and with more turns. An electromotor is used for driving the rollers; the rate is adjusted so that the band moves at about 8 m. per second. The whole of the band passes any given position once in two minutes. As it comes into the field of the "speaking" electromagnet it receives a magnetic impression which it transmits mechanically to the second electromagnet, for reproduction in the telephone. The author says that when a palindrome, such as "Ein Neger mit Gazelle zagt im Regen nie," is spoken into the receiver, it can be distinguished at the telephone whichever way the band is directed. The distance between the receiver and the telephone is not stated. R. A.

334. *Kumberg "Telephonograph."* (Electrician, 45, p. 828, Sept. 21, 1900.)—This is a combination of the phonograph with the telephone. By a simple mechanical device inside the electromagnetic diaphragm call the vibrations of the diaphragm are increased and caused to cut impressions in the coating of a cardboard cylinder 10 inches long and 5 inches in diameter. By revolving the cylinder, record is made at 150 spirals to the inch, and the number of words which may be taken down on one cylinder is some 15,000, equal to a page of ordinary newspaper. There is also a second cylinder, concentric with and at one end of the other, and $\frac{1}{10}$th of its width, the function of which is to take the place of an attendant and to answer calls. The "automatic speaker," in circuit with the microphone mouthpiece and pressing upon this smaller cylinder, can be used to impress a notice upon this cylinder that the subscriber is out, but that a message can be received for him and recorded upon the large cylinder. There are levers for putting each stylus in or out of circuit. When left in circuit for the purpose of receiving messages the movement of the cylinder takes place automatically and is controlled by the person at the distant end of the line who is making the communication. E. O. W.

REFERENCES.

335. *Wireless Telegraphy.* **M. Minolts.** (Elektrotechn. Zeitschr. 21. pp. 808–811, Sept. 27, 1900.)—The Borkum Riff lightship, Borkum lighthouse, and Emden are now in communication by wireless telegraphy. A very good description of the apparatus is given. R. A.

336. *Hertzian Telegraphy with a Telephonic Receiver.* (Electrician, 46. pp. 93–94, Nov. 9, 1900.)—The results of experiments, undertaken by Guarini, are given, and various deductions are made.